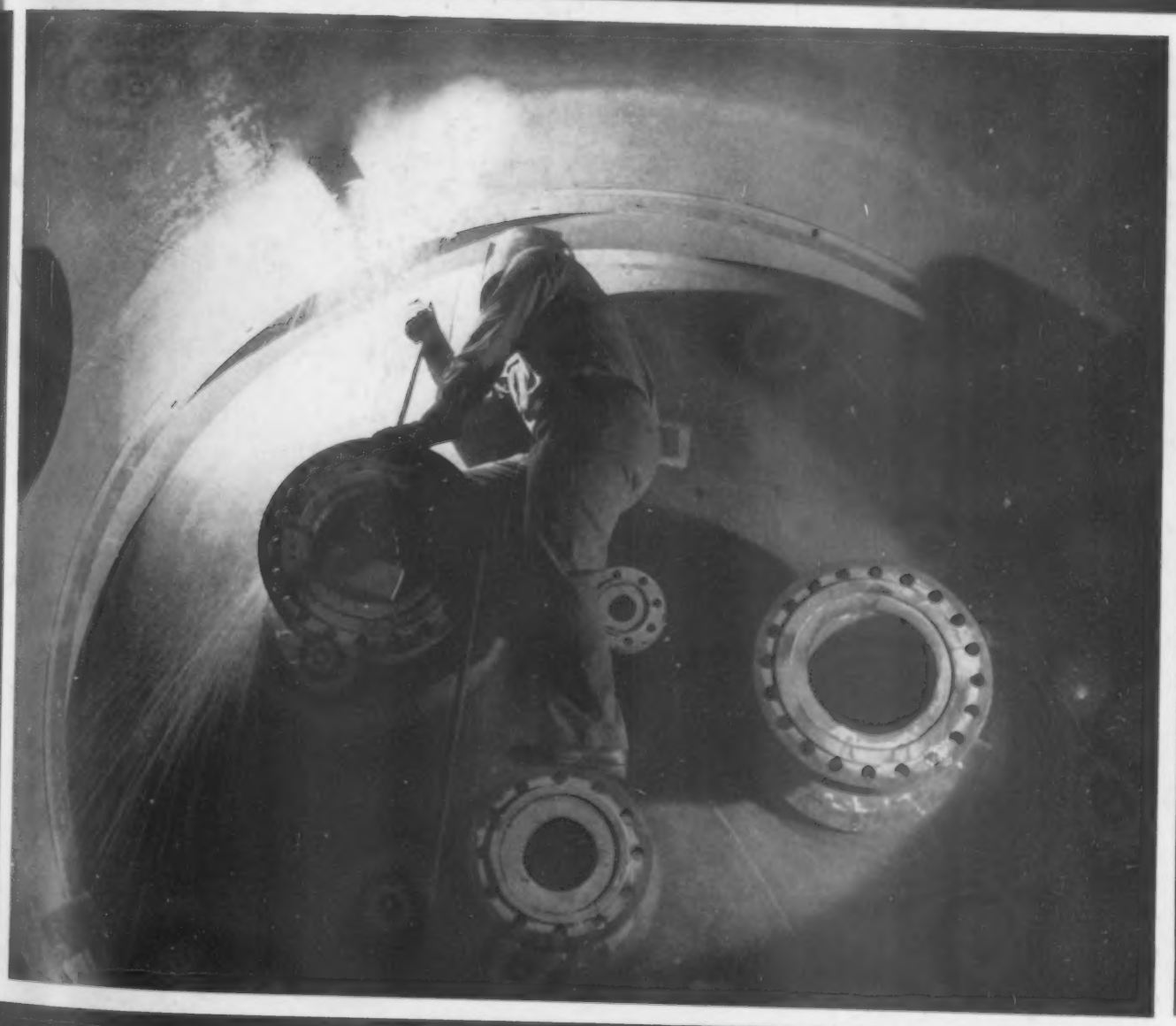
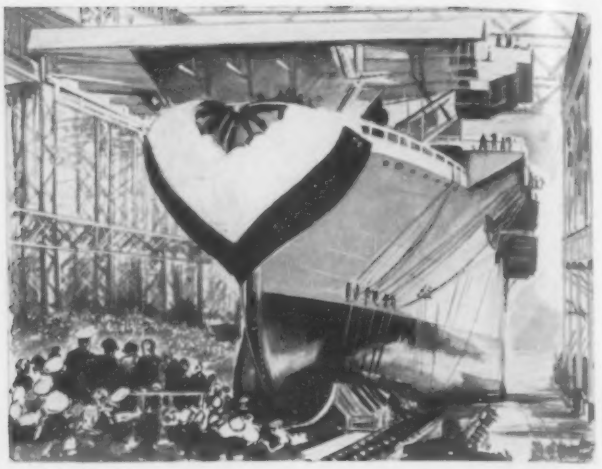
APRIL 1948

The WELDING Journal



The Journal of the American Welding Society



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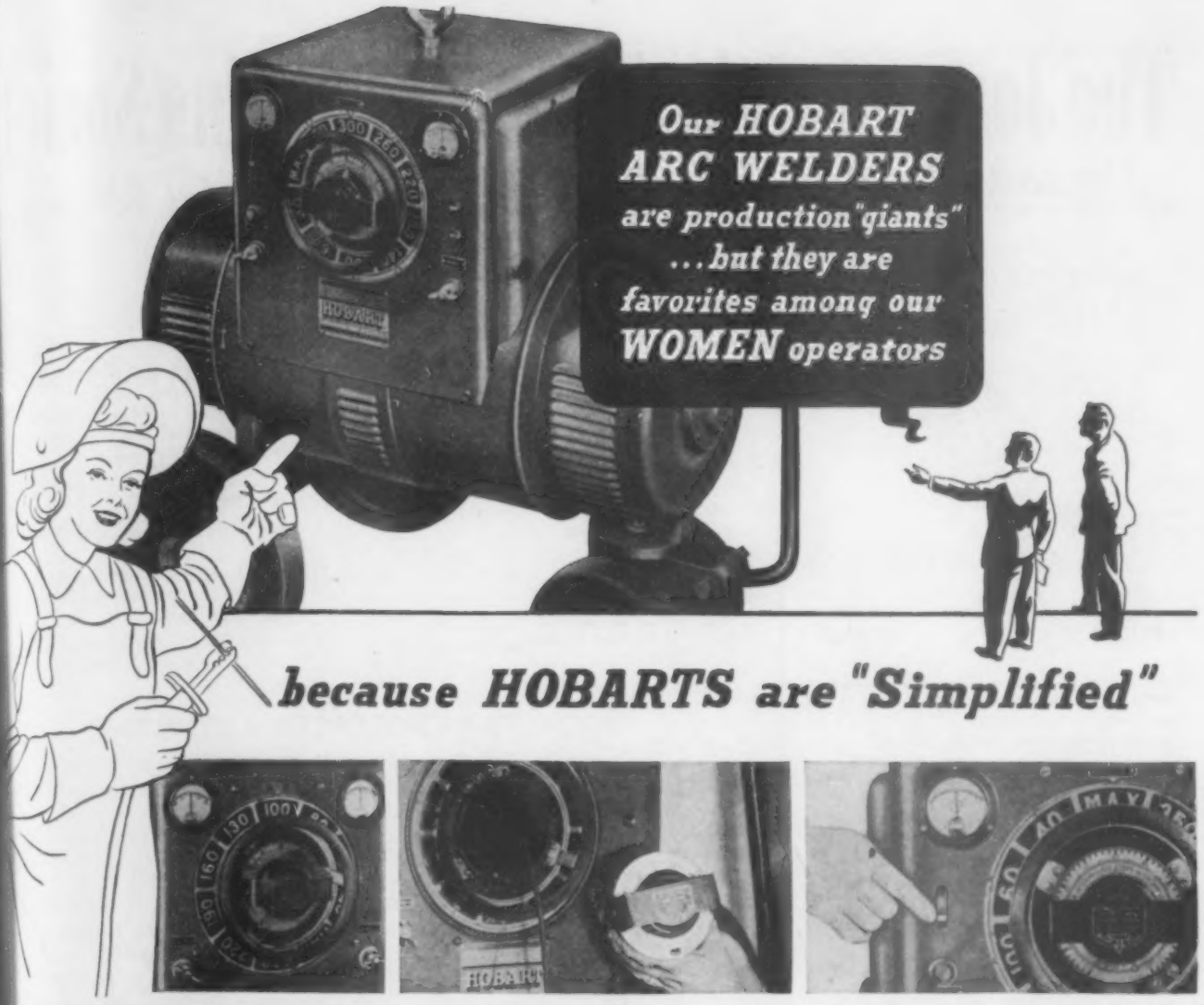

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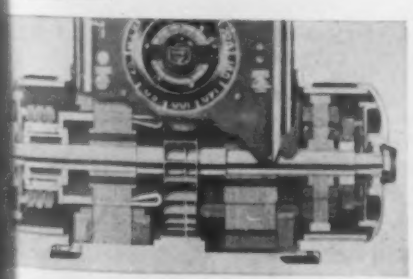

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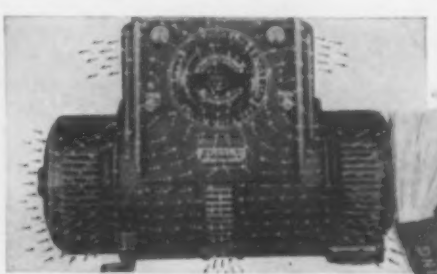

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APRIL 1943

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Welding the Skirt on a Large Pressure Vessel for Oil Refinery Service.

Courtesy, A. O. Smith Corporation.

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Report of the Findings of the Special Sub-Committee Appointed by the American Bureau of Shipping to Investigate the Structural Failure of The Tanker S.S. "Schenectady"

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MR. ERLAND D. DEBES, Welding Engineer, Bethlehem Steel Co., Shipbuilding Division, Quincy, Mass.

MR. LA MOTTE GROVER, Structural Welding Engineer, Air Reduction Sales Co., New York, N. Y.

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MR. HARRY W. PIERCE, Welding Engineer, New York Shipbuilding Corp., Camden, N. J.

PROFESSOR S. H. GRAF, Consulting Materials Engineer and Metallurgist, Professor of Mechanical Engineering, Oregon State College, Corvallis, Oregon. (Consultant on Steel Investigation.)

Ex-Officio Members

J. LEWIS LUCKENBACH, President, American Bureau of Shipping, New York, N. Y.

D. ARNOTT, Vice-President-Chief Surveyor, American Bureau of Shipping, New York, N. Y.

J. L. WILSON, Assistant Chief Surveyor, American Bureau of Shipping, New York, N. Y.

Several meetings of the Committee were held at Portland, Ore., and subsequent meetings at New York, including the final meeting on March 11, 1943.

I—Description of Casualty

1. The S. S. *Schenectady* (503 ft. x 68 ft. x 39 ft. 3 in.) is an all-welded tanker exactly similar in design to ships built and building by the Sun Shipbuilding and Dry Dock Company, Chester, Pa., of which no fewer than 23 have been placed in operation during the past year and which, to the best of our knowledge and belief, have shown no structural defects in service.

2. The *Schenectady* was the first tanker built at the new shipyard of the Kaiser Company at Swan Island, Portland, Ore.; had been launched October 24, 1942, and had satisfactorily completed her sea trials. She was lying afloat at the fitting-out dock of the Swan Island Yard when, on Saturday evening, January 16, 1943, she broke in two with a loud report, fracturing suddenly across the deck at a point just abaft the after end of the bridge about amidships, the fracture extending down both sides to the bottom shell plating which remained intact. All deck, side and bottom longitudinal frames fractured as did also the plating of the corrugated longitudinal bulkheads and the centerline deck and bottom girders thus constituting a complete structural failure except for the flat portion of the bottom shell plating. In no case did the fractures occur in the transverse welds.

3. The vessel jack-knifed so that the bottom shell plating knuckled transversely and showed above water while the ends of the forward and after sections settled in the silt so that there was a gap of about 10 ft. at the deck. There was no leakage of water into the two parts of the tank opened by the fracture and from the character of the fracture the tearing of the side shell appeared to have been more gradual and progressive than the sudden fracturing of the deck from gunwale to gunwale.

4. The forepeak tank, the forward deep tanks, and the afterpeak tank were full of water as ballasted for the trial trip and there were in addition about 3100 barrels of fuel oil in the cross bunkers immediately forward of the machinery space. The resultant bending moment in hogging in still water was about one-half of the maximum design bending moment.

5. The hourly temperature for Saturday, January 16, 1943, reported by the U. S. Weather Bureau for Portland, Ore., shows a high of 38° F. at 2:30 P.M., in the afternoon, and 23° F. at 11:00 P.M. at the time of the failure. The river water temperature was about 40° F. This drop in air temperature of 15° F. over a period of $8\frac{1}{2}$ hr., while not extreme as to suddenness, did introduce a factor in respect of the increased brittleness of steel at temperatures below freezing.

6. It was alleged that during the launching of the vessel trouble was experienced with the after launching poppet which resulted in slight damage to the rudder and its pintle but there was no evidence that such trouble contributed to the failure.

7. It was alleged that during the trial trip one of the anchor chain cables broke as the anchors were dropped to check the vessel's headway, resulting in a definite shock, but this could not have been great enough in magnitude to be of any consequence.

8. It was alleged that the action of the Willamette River had washed a bank of silt under the midship portion of the vessel and that a subsequent drop of river level had in effect caused a stranding. While there was a recorded drop of about 15 in. in water level for the $3^1/_2$-hr. period immediately preceding the failure, there was no evidence of such a silt formation. Subsequent examination of the vessel in dry dock, by the Committee, disclosed no indication of grounding damage.

9. It was also alleged that several people felt a slight seismic disturbance (an earth tremor) at the time of the failure. This was further colored by the fact that the water level indicator located at the yard showed a vertical oscillation of approximately 12 in. at the moment of failure and it is claimed that extreme oscillations of these level indicators always accompany earthquake disturbances. After a thorough investigation it was concluded that the alleged shock had little bearing on the cause of this failure.

II—Factors Contributing to Failure

After a thorough study of all factors surrounding the failure, including structural design, methods of construction and a complete physical, chemical and microscopic exploration of the material and the welding in way of the fracture, the Committee found the following factors relevant and contributory to the failure.

(*a*) There was a tendency on the part of the shipyard personnel to depart from recognized fundamentals of good welded construction for the laudable purpose of speeding up construction to the utmost possible extent to meet the needs of the present emergency.

(*b*) There were insufficient numbers of trained experienced welders and ship fitters available for the job at the rate of production maintained and an inadequate number of skilled welding supervisors with the necessary knowledge of the basic elements of good welding practice to exercise proper control over the welders.

(*c*) There was neglect on the part of the personnel to realize the importance of adhering rigidly to established welding procedures and welding sequences necessary to reduce shrinkage stresses to a safe minimum.

(*d*) There was evidence in the sister vessels under construction of poor fitting of large subassemblies which necessitated considerable forcing into position by the excessive use of jacks, turnbuckles, etc. In other cases open joints required the use of an excessive amount of welding to finish the joint resulting in excessive shrinkage.

(*e*) There was a lack of uniformity in the quality of the steel used in the hull structure. For example, as compared with other plates investigated, the particular sheer strake plate on the starboard side where the fracture apparently started had a very low proportional limit (10,000 psi.) as determined by extensometer readings (stress strain curve); also the Charpy Test impact values for this plate were low, even at room temperatures, and brittle at 20° F.; the values from the Notch Bend Tests also showed considerable brittleness. It should be recognized that the Charpy and Notch Bend Tests are not included in the ordinary commercial tests by which the quality of structural steel is determined.

(*f*) A serious accumulation of shrinkage stresses occurred in the automatic machine welding of the deck assembly joints especially in the longitudinal joint at the gunwale attaching the sheer strake to the stringer plate. This particular welded joint was also found defective in way of the location where the failure started as evidenced not only by a longitudinal crack but also by what appeared to be minute transverse cracks in the weld.

(*g*) The hogging moment resulting from the distribution of ballast, fuel, etc., in the end tanks produced a tensile stress on the upper flange of the hull girder of approximately $4^1/_2$ tons per sq. in., which is comparatively moderate and certainly not sufficient in itself to cause any failure in the hull structure.

(*h*) While there is no question with regard to the sufficiency of the vessel's structure, there being no departure from recognized and proved design standards, the abrupt termination of the bridge-end fashion plates at the top of the sheer strake did constitute a serious point of stress concentration especially in a welded structure.

III—Summary

In the opinion of the Committee the failure of the hull structure of the tanker *Schenectady* was due to a combination of unfavorable circumstances. The principal cause was an accumulation of an abnormal amount of internal stress locked into the structure by the processes used in construction together with an acute concentration of stress caused by defective welding at the starboard gunwale in way of the abrupt ending of the bridge fashion plate, augmented by the hogging stress due to the ballasted condition; this accumulation and concentration of stress caused a tensile failure at the starboard sheer strake which was formed of steel of sub-standard quality, all of which was aggravated to some degree by the drop in atmospheric temperature.

IV—Conclusion

The procedure immediately recommended and carried out whereby the defective welding previously referred to was removed from the S.S. *Schenectady* and sister vessels and these joints properly rewelded has proved a satisfactory corrective measure as demonstrated by the application of severe bending tests (hogging and sagging). It is the opinion of the Committee that the high stresses responsible for the fractures that have recently occurred in welded vessels were due primarily to the failure to adhere rigidly to the procedure necessary to keep shrinkage stresses within the margin of strength allowed in the design. Steps have been taken with the full cooperation of all yards concerned to insure adherence to proper established procedure and the managements of the yards are fully alive to their responsibilities in the matter. The Committee feels that closer control of welding procedure in which the builders have already been instructed will prevent a recurrence of such major failures. It is also the opinion of the Committee that the probability of fractures resulting from residual stresses in welded construction will decrease with the length of service.

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Control of Welding in Shipbuilding

By LaMotte Grover†

Foreword

In a paper* on shipwelding presented not long ago to the Society of Naval Architects and Marine Engineers, by David Arnott, Vice-President and Chief Surveyor of the American Bureau of Shipping, it was said, "That cracks have developed in the plating of our welded ships during construction is generally known, and while such occurrences have been rare, they are naturally and properly the cause for concern . . . ." The author of the article also draws attention to the fact that cold weather greatly aggravates the conditions that may lead to such cracking. Since then, with the advent of more severe cold weather, and with more ships building, than during previous winter seasons, there has been a proportional increase in welding troubles that have been reported. The Subcommittee on Thermal Stresses, of the Marine Committee of the AMERICAN WELDING SOCIETY, has been engaged in the study of these recent reports, leading to an amplification of the report published in THE WELDING JOURNAL in September 1941. The supplementary report, which is intended to deal in definite recommendations of practice, is not yet ready for publication. In the article below, the author, who is a member of the Subcommittee, presents his analysis of the many problems of control, and some recommendations for good practice. While these are his own opinions and do not necessarily represent the unanimous action of the Subcommittee, it is felt that much can be gained by discussion and criticism of Mr. Grover's article. The Subcommittee welcomes comment, which should be addressed to the Secretary of the Committee on Welding in Marine Construction, Mr. William Spraragen at the AMERICAN WELDING SOCIETY'S headquarters.

Harry W. Pierce
Chairman of Subcommittee on Thermal Stresses of AMERICAN WELDING SOCIETY Committee on Welding in Marine Construction, and Member of American Bureau of Shipping Special Subcommittee on Welding. Welding Engineer, New York Shipbuilding Corp.

EXPERIENCE has shown that a combination of several unfavorable circumstances is usually required to cause cracks in welded structures, although very severe conditions in one or two respects alone can result in local cracking. The most important factors for consideration seem to be as follows: (The order of listing should not be inferred to be an indication of relative importance.)

1. Chemistry, soundness, cleanliness and physical properties of the steel (hardenability, lack of toughness to resist cracking, etc.).

2. Thickness of material, which affects the rate of cooling of the weld and consequently the metallurgical reactions as well as other behavior mentioned under Item 10, Cold Weather. Thickness also affects the degree of local stiffness and restraint against weld shrinkage; and thicker material is inherently somewhat less capable of withstanding the kind of strains or working that tends to crack it, a fact well known by anyone who has worked metal. This is probably due to local triaxial tensile stresses (acting in three directions) whether caused by external forces or by weld shrinkage.

3. Degree of rigidity or fixity resulting from types of joints and general proportions and details of the structure, extent of tack welding, etc., *but only in so far as such rigidity results in restraint against weld shrinkage or prevents a dissipation of high local peaks of stress* by plastic flow (permanent set) in the steel. So-called rigid joints or connections for developing continuity between members can be designed and executed so that they will not involve welding difficulties.

4. Stress concentrations caused by notch effects or abrupt changes in section of plates or members, which, if severe, can raise the stresses to several times the nominal stresses as computed by the designer. Stress concentrations are created by sharp corners, nicks in the steel and other things that will be discussed later. Such "stress raisers" may also be created during construction by weld defects (especially undercutting), or by leaving a butt weld incompleted in depth or short of the plate edges and allowing it to become cold before its completion.

5. Process and procedure of welding, including actual dimensions and root spacing of grooves for butt welds, and number of passes, as well as size of electrode, welding current and speed; also direction of welding and welding patterns such as step-back, skip or wandering, block and cascade systems of deposition; also technique or manipulation, and other factors affecting soundness of the welds, for example, accessibility of joints for the performing of the welding.

6. General sequence of executing welded seams and connections, especially those during erection or the closing welds in large subassemblies, which sequence should not result in locking up areas where subsequent welds are to be made. An accumulation of shrinkage effects must also be prevented. Welding should be carried, in general, from fixed points toward points that are more free to move.

7. Thermal stresses and load stresses that may occur at inopportune times during welding or soon thereafter, which may be caused by either contraction or expansion resulting from the welding, or may be caused by changes in atmospheric temperature or by artificial heating or cooling. Reference is made to thermal stresses of such a nature that they would not be taken into account in design because they are not incident to anticipated service conditions.

8. Amount of welding and whether it is continuous or intermittent; also its degree of concentration, especially when a number of heavy welds extending in different directions intersect or nearly intersect at a point which is thus subjected to restrained shrinkage in more than one direction. The provision of an undesirable excess of welding is more common than an insufficient amount, but in a few cases the latter has caused trouble; for example, in case of failure to return welds or "box" them around corners.

* "Some Observations on Ship Welding," reprinted in the February 1943 issue of THE WELDING JOURNAL.

† Member of Special Subcommittee on Welding of the American Bureau of Shipping. Structural Welding Engineer, Applied Engineering Department, Air Reduction, New York, N. Y.

9. Preparation of edges to be welded and the fit-up at these edges; also the trimming and finish of unattached edges such as gunwales, at critical stress points. Some edges require more careful preparation or finish than others.

10. Cold weather, as it affects the notch sensitivity or toughness and other properties of the steel itself; and as it increases the rate of chilling of the joint during welding. In ordinary ship steel this rapid chilling is not likely to cause undesirable metallurgical effects, except, perhaps, in welding thick material in severe cold weather; but it may prevent the deposited metal from remaining in the hot plastic stage long enough to absorb the weld shrinkage.

Some of the factors that have been listed are uncontrollable and sometimes unpredictable; for example, the weather. When some of the conditions are known to be less favorable, tighter control of others is advisable, and perhaps some special precautions such as the warming of the steel to remove the chill, especially at the point where welding is to be started, during severe cold weather. Those factors that can be controlled must be controlled sufficiently to insure good work under whatever other conditions may reasonably be anticipated.

Most of these factors are quite well known. Their effects have been established through experience as well as research; and they have been described in welding literature, for example in various chapters of the A.W.S. 1942 *Handbook*, in various codes and specifications, and in reviews of literature published in THE WELDING JOURNAL. However, the application of such principles in actual practice is not always evident without illustration by examples such as those that will be described later, most of which occurred during cold weather.

Good workmanship should be encouraged in all production. It is found invariably to be more economical when over-all costs are considered. However, a very large majority of the welds in a structure like a ship are not of such a nature that the integrity of the structure depends upon them.

It is important, especially at times like the present, to recognize the comparatively few critical points or strategic locations in a structure, and to exercise particularly close control and supervision at those points. The most capable and experienced welding operator should be used at these places rather than at locations chosen solely because they are especially visible and likely to attract the eye.

Some appendages or secondary members that may not seem very important in themselves, can become quite important when they are welded to main members or material at critical points, as will be explained.

Fig. 2—Welded Girder

(*a*) Liberal sniping of stiffeners avoids concentration of welding. (*b*) Run-off bars at ends of butt-welded splices in girder flanges insure sound welds at edges of flanges.

Critical Points in a Cargo Ship from a Viewpoint of Welding

The inboard profile of a typical cargo ship is shown in Fig. 1. Considering the ship as a girder under hogging and sagging stresses, the middle body is, of course, the most highly stressed in general. Even while a ship is building, changes in temperature of the decks, from day to night, cause bending stresses in the ship, which are especially important when there is a sudden drop of temperature in winter, following a sunny day.

At the house front and the after end of the midship deckhouse there is necessarily a rather abrupt change in the effective girder section. That is why naval architects provide fashion plates to streamline the transition at the sides of some vessels with superstructures extending the full breadth of the ship. It is very important to avoid stress raisers at these critical points. Only a very short distance forward and aft of the superstructure, the girder section must be changed again quite abruptly to provide hatchways for the No. 3 and No. 4 holds. In some ships the corners of the hatchways have been rounded to ease this transition, which is more abrupt by reason of the hatch coamings, which increase the effective depth and section of the hatch side girders at this same point and therefore cause stress paths to deviate more.

Such changes in section must be introduced in any structure as a part of its functional design. However, they should be recognized by shipyard workers as well as designers, hull draftsmen and loftsmen, as areas where particular care should be exercised to avoid severe local notch effects or abrupt local changes, even though they are introduced only temporarily as a result of erection welding sequence and procedure or by the leaving of incompleted welds.

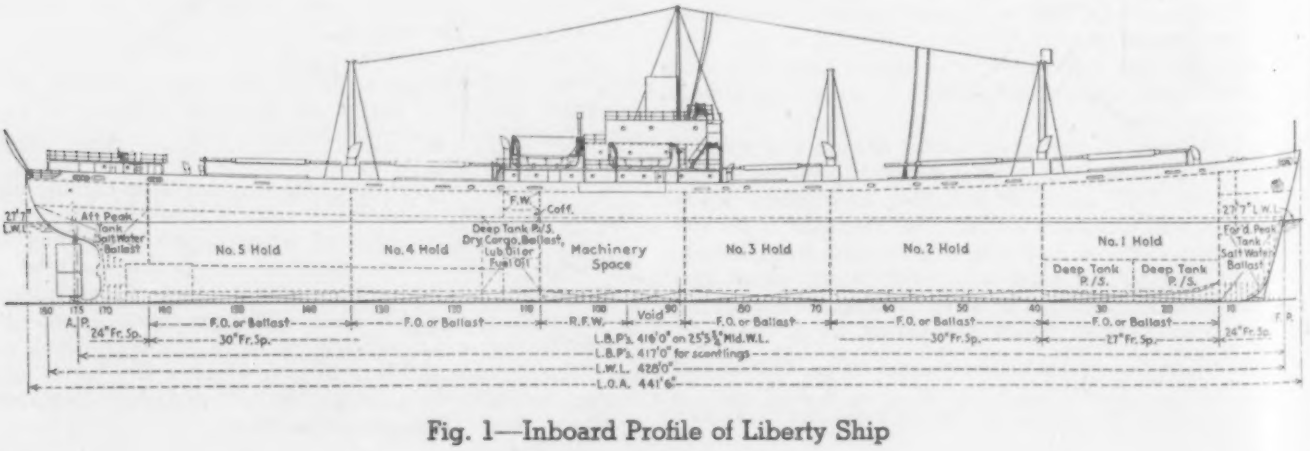


Fig. 1—Inboard Profile of Liberty Ship

Somewhat less critical areas exist in way of other hatches further from the midship section, and at other points which will be mentioned later. In some types of ships there are further critical areas of the same general nature; for example, just forward of the poop in tankers with the weight of the machinery aft. Sometimes, rather abrupt changes in the section of longitudinal framing members determine points where some special care is warranted.

Significance of Extreme Fibers in Sections Subjected to Bending

In any beam or girder (Fig. 2) the fibers of the cross section that are furthest from the neutral axes of bending are most highly stressed. Anyone who has bent rectangular steel bars knows that if the corners are left sharp or if they have nicks in them, they will crack first, in severe bending, because stresses tend to concentrate there. Most specifications for making butt-welded splices in the flanges of beams require the provision of run-off bars at the ends of the welds, which are subsequently removed flush, thus insuring sound metal at the outer corners of the section. Experience has proved this to be advisable.

Since the transverse section of a ship (Fig. 3) is the cross section of a huge box girder, it is evident that the four outboard corners of the section, the gunwales and the bilges, constitute especially critical points. Appendages such as bilge keels, or other secondary parts (for example, bulwarks, waterway bars and hatch coamings), once they are joined to the main material at its extreme fibers, actually behave as part of the main structure, regardless of their intended secondary structural importance. Their details and workmanship, especially in critical areas are very important.

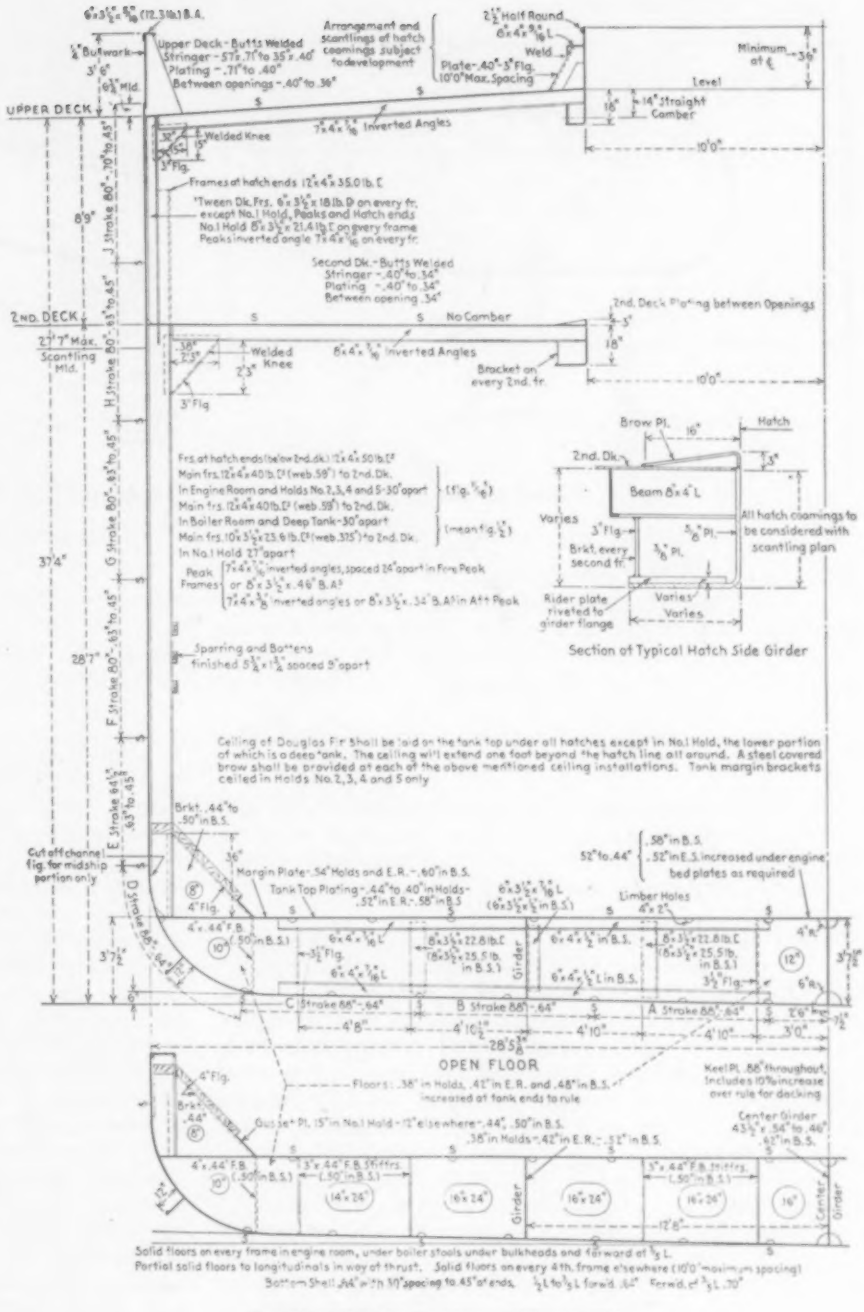

UPPER DECK
2ND. DECK
Welded Knee
Inverted Angles
Frames at hatch ends
Second Dk.-Butts Welded
No Camber
Bracket on every 2nd. fr.
Section at Typical Hatch Side Girder
Ceiling of Douglas Fir shall be laid on the tank top under all hatches
OPEN FLOOR
Keel Pl. .86" throughout
Solid floors on every frame in engine room, under boiler stools under bulkheads and forward at ⅛ L.
Partial solid floors to longitudinals in way of thrust. Solid floors on every 4th. frame elsewhere (10'0" maximum spacing)
Bottom Shell .66" in 7th. Str. spacing to 45° at ends.

Fig. 3—Midship Section of Liberty Ship

Materials

Ordinary carbon steel such as that used for shipbuilding and the construction of bridges, buildings and other common steel structures, is normally of such chemical composition and uniformity that no special difficulties need be anticipated from those considerations. In times like the present, when an unusually large amount of scrap from various sources is being employed in steel making, and when other conditions are not entirely normal, it is possible that occasionally a piece of steel may be encountered which would necessitate some special precautions or limitations in welding procedure, especially in the case of thick materials. Sometimes it is possible to detect unusual qualities in a piece of steel during its fabrication or preparation for welding.

When a steel is of less favorable welding characteristics, it may be advisable to avoid a welding procedure that involves deep penetration and the mixing of a comparatively large quantity of base metal in the weld.

Although most of the steels that are commonly used in structures are readily weldable by well-established procedures, there is no doubt that some improvements can be made to facilitate welding.

A very important consideration is the ability of the steel and weld metal to withstand the various strains or deformations to which they are subjected at the time when these strains occur, either during welding or afterward. This ability is influenced, not only by the normal physical properties of the steel, but also by the prevailing local shape or geometrical form, as well as the temperature of the steel, especially if it is very hot or quite cold.

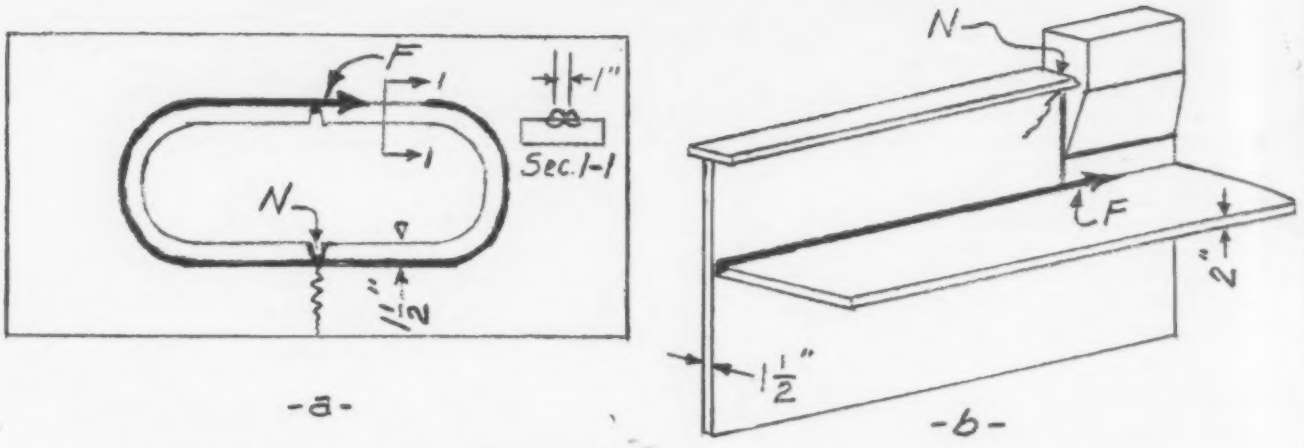


Fig. 4—Effect of Large Expansion Force Combined with Notch-like Stress Raiser

(For further details, refer to The Welding Journal, **21**, 309 (May 1942), "Residual Stresses in Welded Ships" by Harry W. Pierce.)

(*a*) After welding had been completed around both ends and one side, the expansion of welding, *F*, along the other side, caused a crack to start at stress raiser, *N*.

(*b*) Welds designated by heavy lines had been made. Expansion of welding, *F*, caused crack to start at stress raiser at root of groove, *N*, where butt weld had not yet been made at end of flange.

Shrinkage Stresses and Load Stresses

Shrinkage stress, sometimes called residual stress, has an important bearing upon the entire subject of cracking in welded structures. The amount of strain or deformation is often more important than the magnitude of the stress.

When the steel cracks, it is because it is subjected at the point of fracture to tensile stress, arising largely from changes in temperature due to welding and other causes, sometimes accompanied by partial loading of the structure. The crack usually starts where there is a defective weld or detail or some kind of flaw, at the same point where there is a high localized stress. Defects in the steel material may result from fabrication errors, nicks or scars.

A high localized stress often results from an excess of welding required by poor fit-up, or from a large concentration of welds within a small area where there is too much restraint against shrinkage, perhaps because the sequence of welding was wrong. In many cases there is a large further concentration of stress due to a local notch effect, either permanent or temporary, which also prevents the steel material from behaving in as ductile a manner as it normally would. If the stress is almost entirely local at the point where the crack starts, which is usually the case, the crack does not extend very far and it propagates slowly enough that it can be stopped by drilling a hole. The crack can then be chipped or gouged out and carefully rewelded. However, if in addition to the conditions that start the crack, there is a rather wide area subjected to fairly high tensile stress, then the crack may be propagated rapidly clear across the area. Such extensive areas under stress may be caused by an accumulation of shrinkage from improper welding sequence, or by loads on the structure, or by an abrupt change in atmospheric temperature, or by a combination of all these effects, which can combine under some circumstances. The presence of an abrupt change in stiffness, or a row of stress raisers across the area, is a further very influential invitation for the crack to propagate.

If the beginning of the crack is at a critical point in the extreme fiber of the structure, such as the critical points that have been described, then the fracture is much more likely to progress to a serious extent. Therefore, it is very important to guard against defective welds or notch-like details or defects in gunwales, bilge strakes, bilge keels, bulwarks, fashion plates, and waterway bars, and also around deck openings.

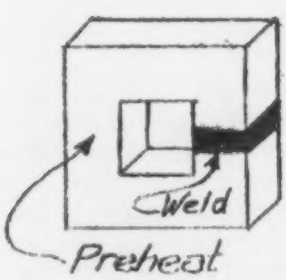


FIG. 5

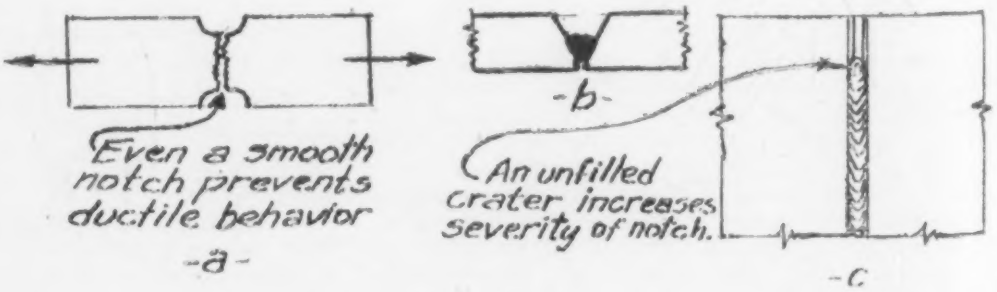


FIG. 6

Fig. 5—Preheating to Provide Shrinkage in One Part That Will Balance Weld Shrinkage in Another Part

Fig. 6—A Butt Weld, Incomplete in Depth (*b*) or Length (*c*) Constitutes a Notch-like Stress Raiser Similar to the Notch in the Steel Bar (*a*)

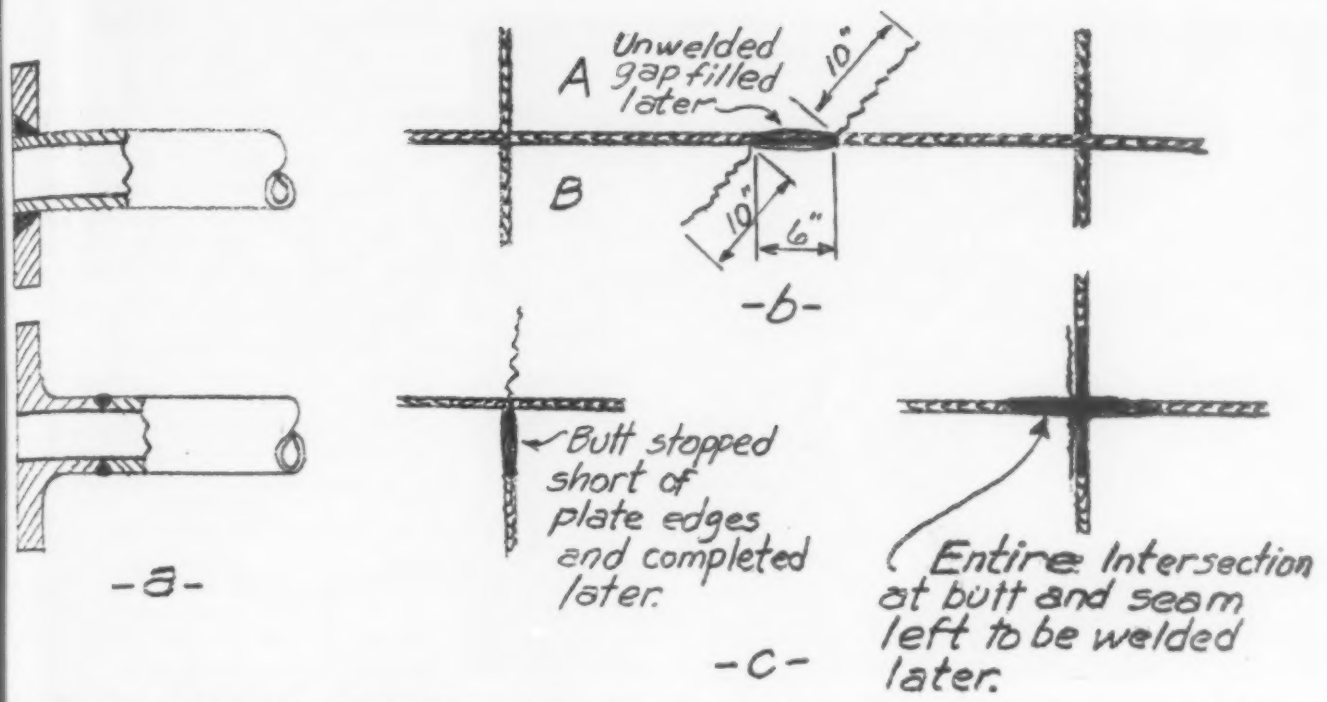


Fig. 7—Restraint Against Weld Shrinkage Usually Results from Improper Welding Sequence, but May Result from Arrangement of Details and Joints

(*a*) Moving the location of a joint can greatly reduce the restraint against shrinkage such as that offered by a circular flange.

(*b*) Short length of groove had not been completely filled. During subsequent welding under restraint, a crack started in the added wide weld layer and later spread into plates, under influence of shrinkage in two directions from butts and seam.

(*c*) Butt stopped short of plate edges and subsequently completed under restraint which caused incipient cracking. Later, after seam had been welded, crack opened and spread into adjacent plate.

A "pick-up" weld (that is, an unfinished part of a weld left for later completion), in a butt or seam is always surrounded by restraint against shrinkage. If it is not made very carefully, it is likely to crack. In the absence of any other stresses in the vicinity, the crack will extend no further because the strain that caused it has been relieved; but at some future date, when circumstances are different, such a crack may spread, if it has not previously been repaired.

The thermal stresses that must be considered are usually the result of contraction during cooling immediately after welding, but rapid expansion during high speed welding on one part of a rigid assembly has been known to exert such severe tensile or bending strains on another part of the assembly, that when this condition has been aggravated by a notch-like stress raiser, cracking has resulted. This condition is illustrated in Fig. 4 (*a*) and (*b*), taken from "Residual Stresses in Welded Ships," by Harry W. Pierce, published in the May 1942 issue of THE WELDING JOURNAL.

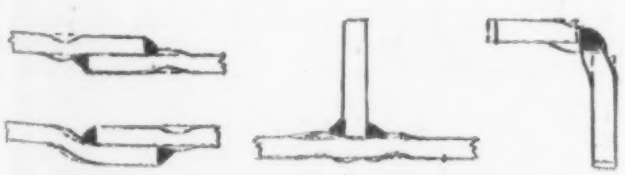


Fig. 8—Thin Material Can Deform More, Locally, Than Thick Material

(Refer to p. 142, A.W.S. 1942 Handbook.)
Note that deformations are greatly exaggerated for clarity.

When a butt weld is left unfinished and allowed to become cold, and high local heat is then introduced by restarting the weld during cold weather, the expansion will sometimes start a crack, especially if there is an unfilled crater with a fissure in it at the end of the incompleted weld.

When two parts of great difference in thickness are welded together, the lighter material may expand so much faster that high shearing stress will be developed in the weld, unless step-back or block welding is used to break up this effect, or the heavier part is preheated.

Preheating is also used to advantage for providing shrinkage in one part of an assembly to balance weld shrinkage in another part which would otherwise be seriously restrained. A simple case is illustrated in Fig. 5. However, careful consideration must be given to the effect of preheating in each case before it is used. For example, if this same part, shown in Fig. 5, were of heavy material to be welded in severe cold weather, and preheating was desired at the weld, then the entire part might well be preheated. Extensive preheating only in the vicinity of the weld zone would just add that much more shrinkage in the leg being welded; but the weld zone could be warmed up locally somewhat, say to 70° F., without introducing much more shrinkage.

Notch Effects and Other Stress Raisers

It has been mentioned that general changes in section (such as that in the hull girder at a house front), which are necessary in any design, constitute somewhat critical points; but their effects as stress raisers are not serious unless there is also a severe local notch effect or an ac-

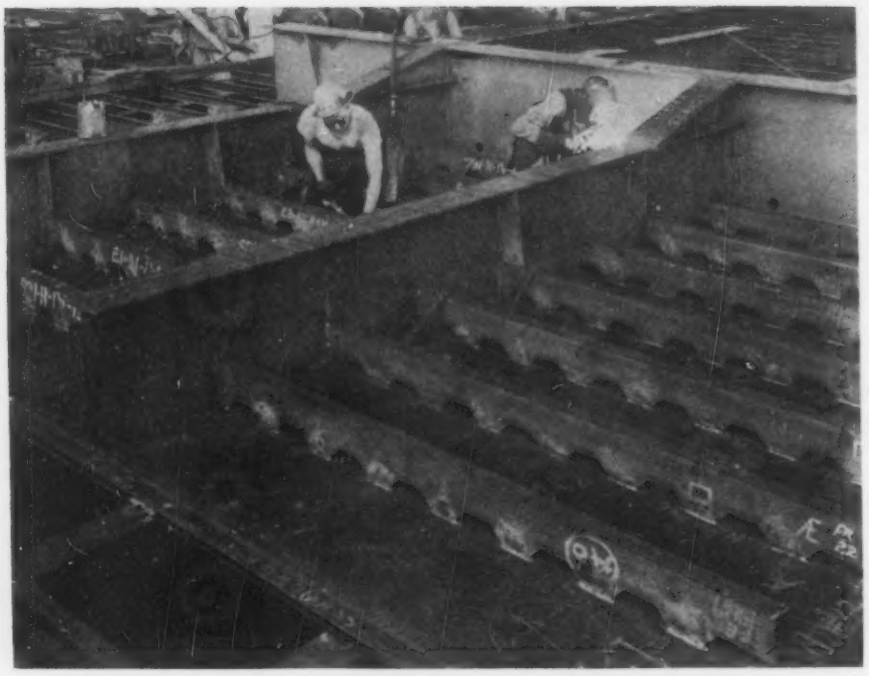


Fig. 9—Members with Serrated Edges Overcome Objections to Intermittent Welding and Afford Other Advantages

cumulation of local stress raisers, the effects of which may be pyramided one upon the other. Hull draftsman and loftsmen must be careful to avoid notch-like details and sharp corners, or an accumulation of abrupt changes in scantlings, or other kinds of stress raisers such as deck openings, hull fittings, etc., all in the same transverse section of the hull girder.

Hull fittings should be located at less critical points wherever practicable. For example it has been proposed to weld bulwark brackets to the stringer strake of the deck, not too close to the gunwale, and to avoid all welding of such details to the sheer strake (Fig. 11). It is especially important to keep the gunwale smooth and free of scars or defects.

Where doublings must be used their corners should be well rounded. Doublings or heavy insert plates should not be terminated too close to other details such as brackets, stiffeners, chocks, etc., which tend to change the stiffness of the structural parts rather abruptly. Plug welds in doublings should be held to a minimum. Often a heavy doubling or insert plate defeats its purpose by adding severe local stress concentrations at a critical point.

One of the best simple illustrations of a stress raiser due to shape or form is a butt weld with abrupt excess "reinforcement." Repeated stress tests have shown that an abrupt hump of this kind on the surface of the plate greatly reduces fatigue strength. Although the hull of a ship is not thought of as subjected to serious fatigue stresses, there is much that has been learned from fatigue tests that has some general bearing upon all structural behavior under less severe conditions of loading.

Everyone knows that a bar or a plate is more likely to crack or break when a notch is cut in it because such a notch makes the steel act in a less ductile manner and prevents high peaks of stress from being ironed out and distributed as readily. In flanging plates during cold weather, even center punch marks on the bend line have caused cracks to start. An incompleted butt weld with the groove not filled or stopped short of the plate edges (Fig. 6) and allowed to get cold, constitutes a similar temporary notch effect which can cause trouble under some circumstances, particularly in cold weather. At critical points, especially, butt welds should always be carried through to plate edges. Run-off bars should be provided during welding and then be removed flush to avoid defects that might start a crack. In vertical butts the run-off bars may be omitted if the weld can be built up without them in such a way that no defects will remain after the excess metal is removed. Sound metal is especially necessary at extreme fibers, for example at the gunwale. When excess stock is left to be trimmed off after erection, it must be remembered that a notch effect or defect such as a crack in an unfilled crater at the temporary edge of the plating may cause trouble if it occurs at a critical point.

When a cracked weld is not chipped out for its full depth or length, the remaining part of the crack constitutes a severe stress raiser, and the crack may migrate up through the newly added weld metal during re-welding.

Defects near the surface, such as pronounced undercutting transverse to the direction of stress are very objectionable.

The cracking of too small a root pass in a butt weld is a case of a temporary notch effect combined with such rapid chilling that shrinkage cannot be absorbed in the weld metal while it is hot and plastic. Also, a very small bead of weld metal deposited on thick material in severe cold weather may be chilled so rapidly that part of the metal in the weld zone will be transformed to martensite with an accompanying increase in hardness and decrease in ductility. Subsequent passes will anneal the root pass, but they will not remove a crack if one has been started. If the welding sequence is such as to create a severe restraint against shrinkage, or if the weld groove is too wide and the excess welding increases the shrinkage, these conditions added to the others, make matters that much worse. Too wide a root face or too small a root opening can also cause trouble by preventing the deposition of a sound adequate root pass.

Degree of Restraint and Rigidity

High shrinkage strains can result from a severe amount of local restraint against weld shrinkage. Such restraint is usually caused by improper welding sequence; but unsuitable details or arrangement of details or location of joints, can cause the kind of local stiffness or rigidity that imposes excessive restraint against shrinkage or prevents dissipation or ironing out of high local peaks of stress. A simple case is illustrated in Fig. 7 (*a*).

General statements regarding rigidity or stiffness are likely to be misunderstood. Any additional stiffness in the hull girder, as a whole, which results from welded construction is beneficial to the structure. Likewise, general stiffness in beams and girders is beneficial, as well as rigidity at connections where continuity is desired to reduce bending moments and deflections or to resist racking, and where such continuity is assumed in choosing the scantlings. Of course, the welding of these connections must be sufficient and properly disposed to develop the continuity.

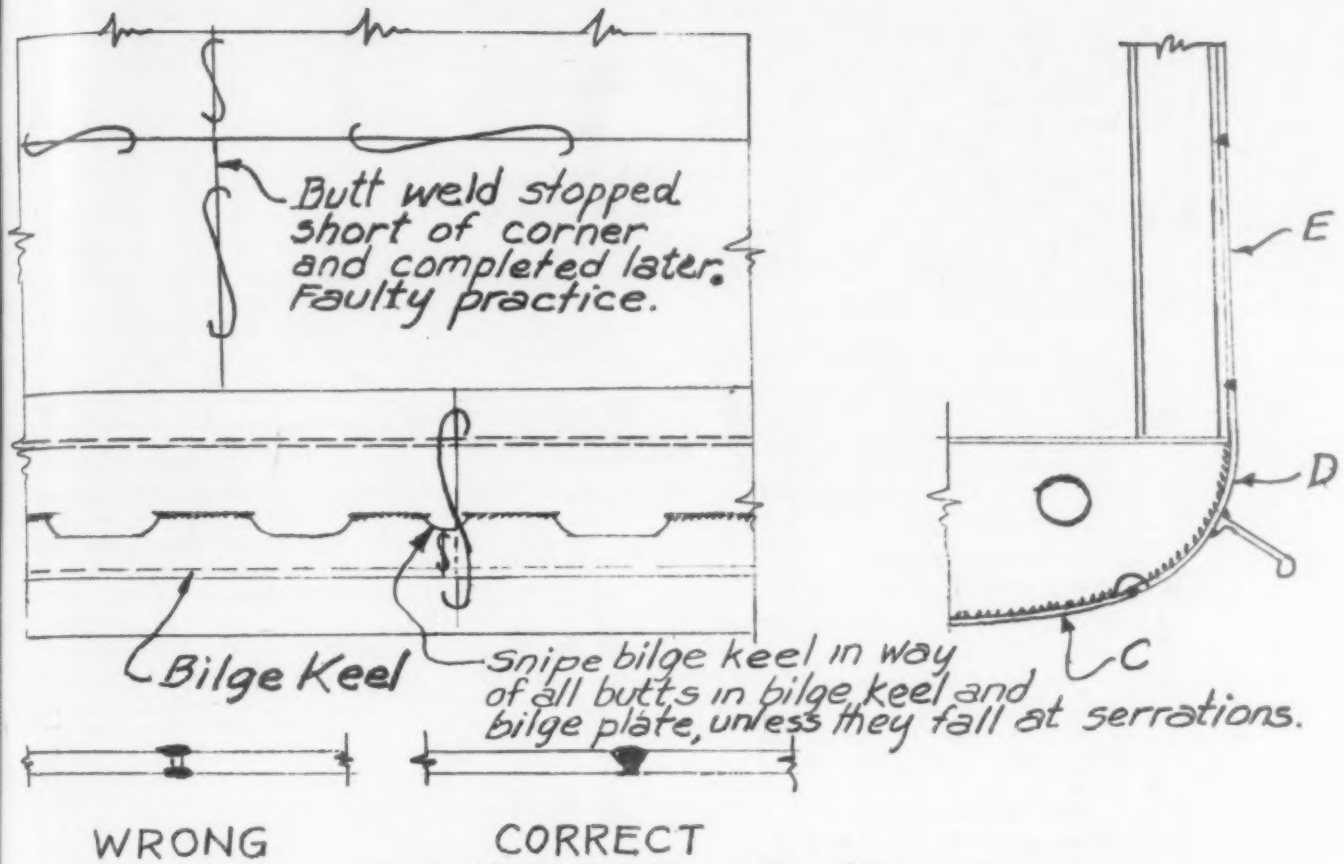

Butt weld stopped short of corner and completed later. Faulty practice.
E
D
C
Bilge Keel
Snipe bilge keel in way of all butts in bilge keel and bilge plate, unless they fall at serrations.
WRONG
CORRECT

Fig. 10—Details at Bilges of Cargo Ship

It is important to use arrangements of details that will permit a proper sequence of welding to be used, and which will not encourage a progressive tearing action, and will not introduce notch effects or too abrupt a change in stiffness at critical points. This latter will be discussed later in a typical example (Fig. 17) which involves a number of factors contributing to trouble.

Nearly everyone recognizes conditions of extreme restraint such as that around an insert plate or patch plate which is surrounded by material on all sides while it is being welded in place, or the restraint when a butt weld is made in a short bar which has its ends tied into relatively fixed members so that there is not much length to stretch and absorb shrinkage from the weld.

Some other conditions of severe restraint do not seem to be as well recognized, for example, during the pick-up welding of gaps that have been left open, either in the middle of a butt or seam in plating, or at the end of such a butt weld (Fig. 7 (*b*) and (*c*)) especially when the pick-up welding is done after the plates have become cold.

When there is stiffness or restraint in more than one direction as at a gunwale or at a bilge, or at any T-joint or corner joint, more care must be exercised than at an edge-to-edge joint. Wide plates in themselves offer more local restraint than narrow plates, and high peaks of stress are not as easily ironed out. If the material is quite thick, step-back or block welding should be used.

Thick material cannot deform as much, adjacent to the weld, to relieve shrinkage stress as thin material can (Fig. 8). Also the heat of the welding does not penetrate as much as it does through thin material, and the fibers on the side of the plate opposite the hot weld metal exert some restraint. This effect can also cause cracking in a wide layer of weld metal added to fill a groove that has previously been only partly filled and allowed to become cold (Fig. 7 (*b*)).

A good example of severe restraint is the condition when intercostal diaphragm plates must be welded between girders or other members on all four sides of these diaphragms, which condition may occur in machinery foundations, skegs or other heavily stiffened assemblies. Shrinkage will accumulate if a sequence of welding is not maintained to provide for completing the welds progressively in a general direction that will permit a reasonable amount of freedom for contraction. If several of the welds are passed up or not completed, a very severe condition of restraint will exist when they are picked up later.

Butt welds have been proved to be very much superior to fillet welded joints such as lap joints or joggle joints, for important highly stressed connections, but there is more shrinkage in a butt-welded joint than in a fillet-welded lap. For this reason there are many places where fillet welds are preferable to butt welds, especially

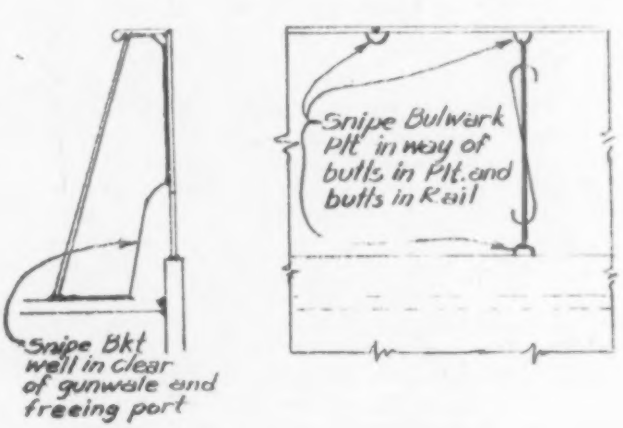


Fig. 11—Sniping of Bulwark Plates and Brackets

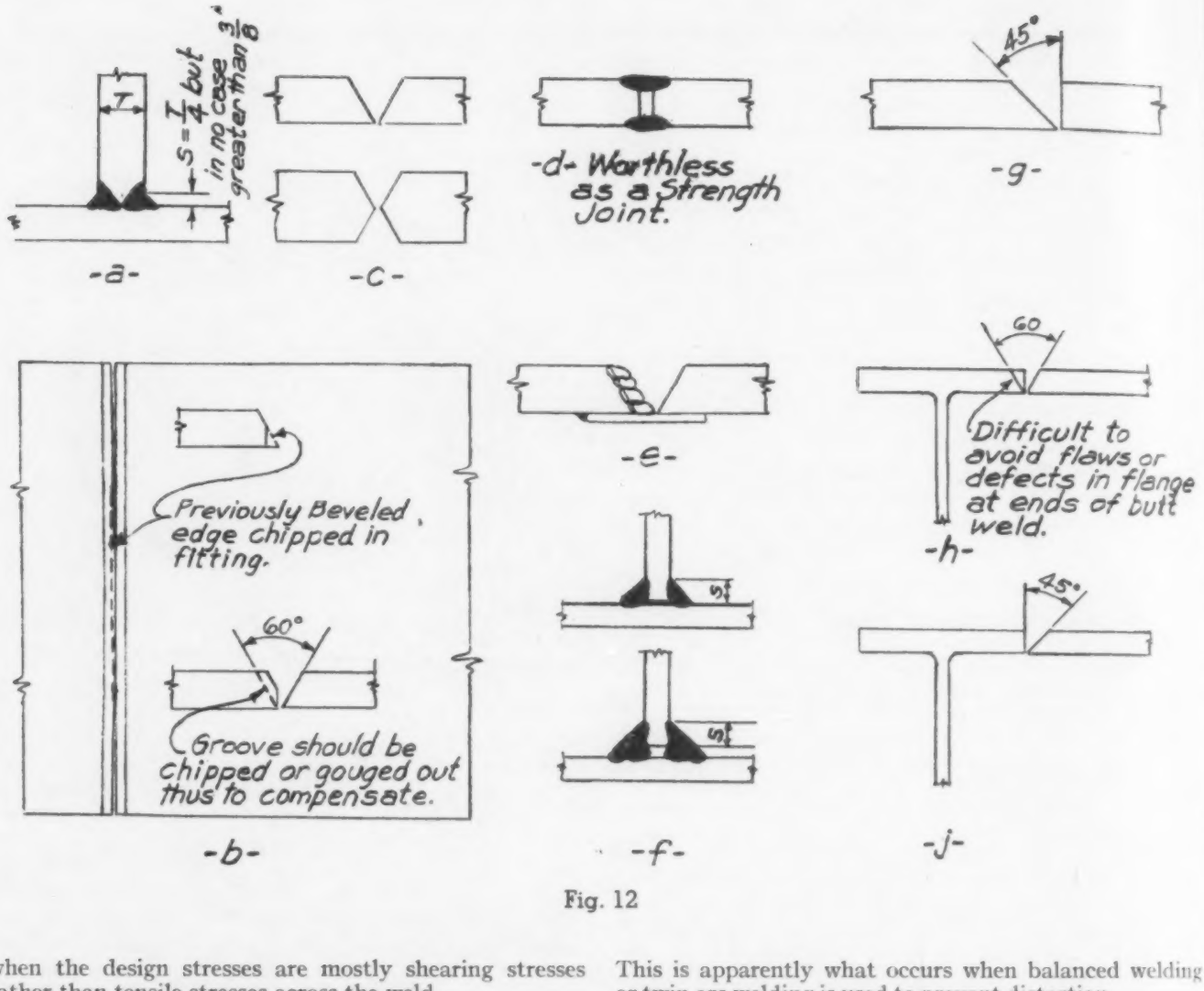


Fig. 12

when the design stresses are mostly shearing stresses rather than tensile stresses across the weld.

The extent of tack welding and the size of tack welds has an important bearing upon restraint. Tacks can be made light enough to break before they result in too much restraint (provided that those which crack are chipped out ahead of the finish welding). A better alternative in most cases seems to be to make the tacks heavy enough to hold the parts properly in shape, but to avoid tack welding so far ahead of the finish welding that shrinkage will accumulate to a serious degree. The distance that fitters and tackers can safely get ahead of the welding on a ship should be less in welding heavy material and also less during cold weather.

Some shipyards have a rule that is rigidly enforced in the tacking of edge-to-edge butt welds, to the effect that no tacks shall be made closer than 12 in. from the intersection of a butt with a seam. The manner in which these corner grooves sometimes close up during subsequent fitting and welding operations demonstrates the relief that is afforded by enforcing this rule.

A certain amount of restraint such as that from tack welding, or strongbacks at butt welds, is indispensable in controlling distortion. In some cases, if distortion is alllowed to occur, the fairing required to correct the distortion may subject the parts to much more severe strains than those that would result from the amount of restraint required to prevent the distortion, especially if heavy jacking is involved in the fairing.

A reasonable amount of restraint will not cause high shrinkage strains because a large part of the shrinkage is absorbed in the weld zone while it is hot and plastic. This is apparently what occurs when balanced welding or twin arc welding is used to prevent distortion.

When a very high-speed welding process is used for making a butt weld, the tendency often is for the plate edges to spread apart ahead of the welding rather than to draw together as they do when slower welding speeds allow the heat to soak out farther away from the joint. The longitudinal expansion and contraction are important factors in this phenomenon. Sometimes a crack will occur at the end of the joint if the two plate edges are not tied together there with a strongback. If the strongback is properly located and is deep enough, it can be made to resist angular distortion also at the end of the butt weld where this tendency is most pronounced.

Sequence of Welding

Many specifications for welding include a general rule that the direction of progression shall be from points that are already fixed in position toward points that are more free to move. This usually means that welding starts in the center of an assembly and progresses outward in all directions, or in the case of erection welding on a ship, forward and aft and outboard. This rule is quite well known in all shipyards, but it is frequently violated. Of course, in back step welding the actual direction of welding is opposite to the direction of progress.

Another well-known rule, based upon the same general principle, is that in welding shell plating, decks, etc., the welding of a seam shall not be carried past a butt that has not been completed out as far as the next unwelded seam outboard or in the direction of progress. Violation of this rule of welding sequence has led to a good many

of the cracks that have occurred in welded ships. Perhaps the rule is violated more in assembly welding than in erection welding where its violation is somewhat more likely to be serious.

The stopping of a butt about 3 or 4 in. short of the plate edges at the next seam, to facilitate fitting to the next strake of plating, is a great temptation (Fig. 7 (*c*) and 10). This in itself may not cause trouble, except in cold weather or when end craters are left unfilled; but a very objectionable condition develops if the seam is carried past before the butt is completed (and extended on across the next strake in case the butts are not staggered). An equally bad condition exists, if not a worse one, when the butts and seams are all stopped short of an intersection and this cross-shaped gap is welded up afterward. When conditions such as these occur, it is very difficult to avoid weld cracks which sometimes extend into the adjacent plate material. Some cracks that have occurred in bilge stakes have been caused by such conditions. The multidirectional stiffness at the curved bilges, stiffened by the floor ends, increases the probability of trouble when welding sequence is violated or when excess weld metal results from poor fit-up.

When other parts are to be welded to the plating, such as the bilge keel, margin plates and ends of floors, this welding should be carried along in proper sequence with the welding of butts and seams, so that shrinkage will not accumulate. The direction of welding is also very important. For example, butts in bilge keels should be welded outward toward the free edge.

If an appendage like a bilge keel, at a critical place in the hull structure, is left to be welded on after the plating has been welded together, and if it is welded in place while there is a hogging moment in the hull girder due to differences in temperature between the decks and parts below, then the appendage will have a higher residual stress than the main hull. Although such higher stresses usually become ironed out in service, it is best to avoid risk of their becoming a contributing factor to trouble, and to work the welding of such appendages into the sequence for other welding.

This introduces another rule, included in many welding specifications, that all the fittings, appendages and attachments be welded to a part or member, in so far as practicable, before the part or member is welded to other parts of a structure or assembly. This is for the purpose of causing as much of the shrinkage as possible to occur before the member is under restraint, so that an accumulation of a large amount of shrinkage will be avoided. An especially undesirable procedure is to weld a heavy part such as an edge reinforcing bar to a light member or plate after it has been welded into a structure or assembly, for example, edge reinforcements on rails, coamings, bilge keels, etc., or bulb bars welded to the edges of bulwarks or fashion plates.

It would be ideal from a shrinkage stress viewpoint to weld all hull fittings, bases for deck machinery, doublings, insert plates, etc., to the plating before it is tied into the ship by the erection welding. This is being done to quite an extent in some shipyards where large subassemblies are completed on the ground. The heavy welding required for a group of deck fittings sometimes affects the deck structure over a large portion of the length of the ship when this welding is done after the deck sections are all erected and tied together, as evidenced by distortion during such welding. When such fittings or appendages are not available or cannot be welded to the plating in advance, or when there are other welding or flame straightening operations to be performed after erection, some shipyards leave a transverse butt unwelded in the deck to prevent an accumulation of shrinkage. Some extra stock must be left so that the butt can be carefully fitted and welded later on. This procedure introduces complications at the sides of the ship where the longitudinal seam between the deck and the sheer strake must be left unwelded for several feet forward and aft of the deck butt until it is finally welded. At the best, this leaves a length of longitudinal seam, at a critical point, to be welded last while it is surrounded by restraint. However, if the deck stringer plate is fillet welded to the side shell, the closing of such an unwelded portion of the joint does not involve as much shrinkage.

Welding rules often include a clause specifying that whenever a choice is possible in making the closing welds in a structure, the welds that will shrink the most shall be made first, for example, butt welds before fillet welds.

A common practice in subassembly welding is to fit and tack and sometimes to finish weld deck beams, girders, stiffeners, etc., to the plating across seams before the seams are welded or at least to do this when only the backing passes for the seams have been made. Then the assembly has to be turned over only once for the main welding of the seams to be performed from the unobstructed or smooth side. This saves time and handling and there seems to be no direct evidence of its causing trouble. The practice might be questioned in the case of very heavy plating and severe cold weather, when the butt weld may not remain hot and plastic long enough to absorb much of its shrinkage. The deck beams or stiffeners are usually intermittently welded to the plating with no welds too close to the points of intersection with the seams. If the webs of the beams or stiffeners are quite thin, however, this practice can cause them to buckle in way of the seam.

Heavy insert plates at hatch corners are sometimes left out to facilitate the erection of hatch-beam-and-girder assemblies, and the insert plates are then welded

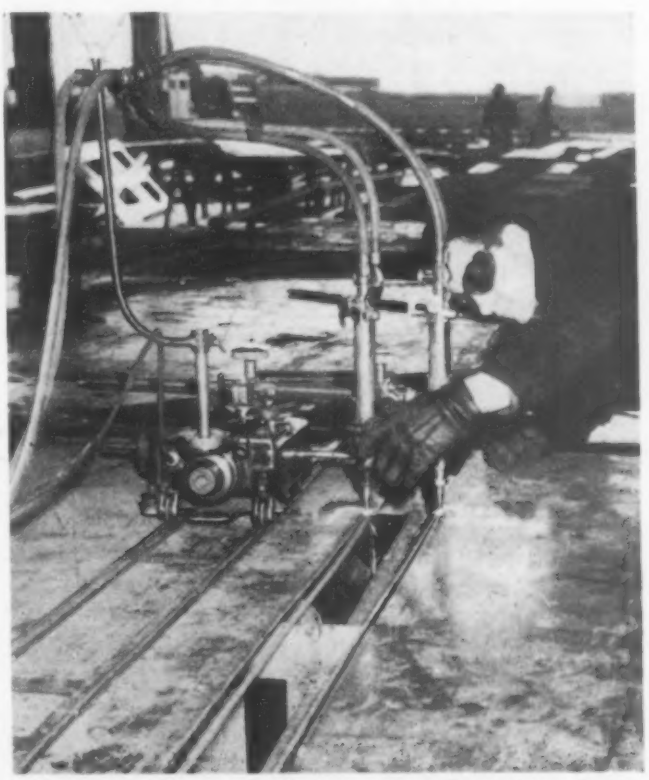


Fig. 13—Simultaneous Trimming of Both Edges for a Seam, with Both Torches on the Same Machine, Facilitates Good Fit-up

in place after other welding in the vicinity is completed, thus creating a very severe condition of restraint, which could be avoided by a change in sequence of erection or in some cases by merely changing the sequence of welding

Amount of Welding and Its Disposition

Since shrinkage strains arise from the heat of welding, it is very important that the amount of welding be held to the minimum requirements. The narrowest groove for a butt weld that will permit a sound weld to be made is the best type. Often continuous welds are used where sufficient strength would be provided by intermittent welds, and where there is no requirement for continuous welds to protect against weather or to provide oil or watertightness.

Sometimes continuous welds are specified out of a desire to seal joints against corrosion. If members with serrated or scalloped edges (Figs. 9 and 10) are used for deck beams, bilge keels, longitudinals, etc., the intermittent welding can be sealed off by returning the weld increments around the ends of the teeth between serrations, which is desirable from technical considerations also.

If a crack starts in the plating as a result of some casualty, serrated webs of beams or longitudinals discourage the propagation of the crack from the plating into the member. Also such serrations provide circulation and better ventilation under deck heads in dry cargo holds and they facilitate the cleaning and purging of tanks.

Concentrations of welding should be avoided as much as possible, especially when they involve welds extending in several directions. In girders this can be avoided by sniping corners of tripping brackets or stiffeners liberally (Fig. 2). The webs of bilge keels should likewise be sniped liberally in way of all butts in the bilge keel itself as well as all butts in the bilge strake (Fig. 10). This also facilitates sound welding. Likewise bulwark plates can well be sniped or scalloped in way of butts in them and butts in the rail. Bulwark brackets should be sniped well in the clear of the gunwale. (Fig 11.)

An objectionable concentration of welding results when a heavy deck fitting is located near the intersection of a deck seam with a deck butt.

Sometimes butt welds are specified at T or corner joints where they are not needed for strength, and two fillet welds would cost less and contain less welding to cause distortion and shrinkage strains. When a butt weld is required because of the kind and magnitude of the stress at a T-joint, only very small fillet welds are usually specified (Fig. 12 (*a*)) to avoid a sharp notch effect in the corners.

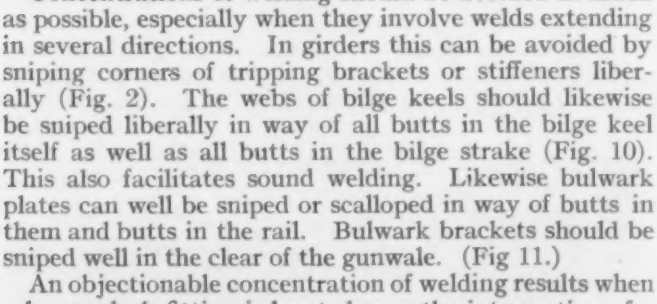


Fig. 14—Guided Manual Cutting for Trimming Bulkheads to Fit Them to Decks

Fig. 15—Machine Gas Cutting to Insure Close Fit to Side Shell

Tripping brackets, stiffeners, etc., should be held to the minimum actually needed, in the interests of economy as well as the reduction of shrinkage. Tripping brackets are sometimes provided at the end connections of beams when they are not needed to develop continuity and they are not located in positions where they could contribute appreciably to resistance to racking.

If heavy built-up beams and girders are made in symmetrical shapes, such as an inverted T or an I shape rather than an L shape, then there is less need for tripping brackets to prevent lateral deflection which tends to occur when the stress distribution is unsymmetrical.

Fit-Up and Preparation of Edges for Welding

Many of the difficulties experienced in welding result from fabrication errors and poor fit-up and the severe forcing of parts to obtain a fit-up. This is partly due to inexperience and carelessness, and partly because of failure to allow for the contraction of welding.

An inaccurately prepared plate edge results in too wide a gap and excess weld metal in places, sometimes over a short length where the gas cutting operator carelessly gets considerably off the line of cut. The result is a large local concentration of weld metal and its accompanying shrinkage.

Sometimes a previously beveled edge for a welding groove is chipped in fitting (Fig. 12 (*b*)) so that the groove is made narrower and the root face or "land" made too

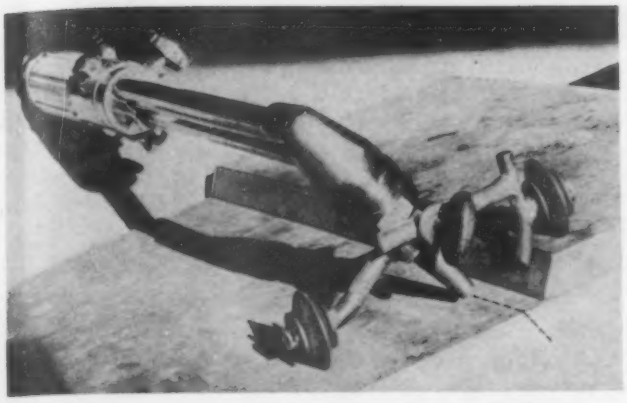


Fig. 16—Accurately Guided and Controlled Manual Cutting as Used for Simultaneous Trimming and Beveling of Plate Edges in Fitting Side Shell Seams During Erection

deep. If the groove is not chipped or gouged out to compensate for this, it is impossible to deposit an adequate root pass with good penetration. The simultaneous trimming of both edges for a seam, with both torches on the same machine, facilitates good fit-up (Fig. 13).

For manual welding, many shipyards have now adopted the beveling of plates to a "feather edge" (Fig. 12 (*c*)) to insure proper penetration. Of course the weld shown in Fig. 12 (*d*) should not be tolerated at any place in the structural parts of a ship or in any part that is attached to structural parts.

For trimming bulkhead during their regulation and fitting to decks, guided manual cutting (Fig. 14) produces a satisfactory edge, although trimming with a gas cutting machine may be just as economical in the long run, or preferable in some cases. Where finish or accuracy is very important, as in trimming the top of the sheer strake, or trimming a deck plate or inner bottom to obtain close fit-up to the side shell, machine cutting should be mandatory (Fig: 15).

Manual cutting, accurately guided and controlled by devices such as the one shown in Fig. 16, has been found very satisfactory for producing uniform accurate grooves for seams in shell plating, where extra stock has been allowed for trimming during fitting.

When poor fit-up results in too wide a groove, one edge can be built up first as shown in Fig. 12 (*e*), before the gap is bridged, thus preventing the shrinkage of the entire amount of weld metal to accumulate. If the backing strip is fillet welded in advance along both its edges, it must be thin enough that the heat of the root pass will penetrate through it and heat it enough that it can yield. It is well to just tack the strip in place lightly and remove it, if practicable, after the joint is welded, although a sound weld can be made on such a backing strip.

An excessive gap at a fillet weld requires excess welding and more shrinkage, to obtain the correct effective weld size, "*S*" (Fig. 12 (*f*)). However, for manual welding, a substantially perfect fit-up as between a planed edge and a ground surface is not deemed advisable. A slight clearance before welding provides a desirable allowance for shrinkage.

In one of the general examples to be discussed later, the effects of poor fit-up and severe forcing will be illustrated.

Welding Procedure and Sound Welds

Research has shown that small gas pockets and slag inclusions, well scattered, do not lower the strength or affect the physical properties of a welded joint seriously. Slag layers and lack of fusion at the root of a butt weld, which result from poor access for making the root pass or failure to chip and clean out the root before welding from the opposite side, are more serious defects in an important joint. Weld cracks, either interior or on the surface, and other surface defects like crater defects, pronounced undercutting and overlap are the most serious. All these can be eliminated by proper welding procedure and sequence.

The choice of current values, sizes of electrodes and welding speeds depends not only upon thickness of material, type of joint and position of welding, but also upon the weldability of the material, as mentioned under Materials, and perhaps to some extent upon the direction in which shrinkage is most objectionable in any particular case.

There seems to be general agreement that when transverse shrinkage or angular distortion is the most objectionable, a high rate of heat input is advisable, and as large electrodes and as high welding currents should be used as possible without detracting from the soundness of the weld, and without introducing so much concentrated heat that the material cannot maintain its shape locally.

In the case of a corner joint or T-joint which is quite stiff in two directions, longitudinal shrinkage is more restrained. Under these circumstances smaller electrodes and lower welding currents seem advisable.

Step-back welding, and block welding, in the case of thick material, are quite well recognized as effective in reducing both transverse and longitudinal shrinkage strains.

There is some controversy as to whether a single bevel groove or a V-groove (Fig. 12 (*g*) or (*c*)) is best for edge-to-edge butt welds. The former involves less shrinkage but may require a more skilled welding operator. Experience has shown that it is not advisable to bevel the edge of the flange of an important beam where a plate is to be welded to it (Fig. 12 (*h*)) unless very special care is taken to avoid defects or scars at the ends of the butt weld. It seems that the preparation shown in (Fig. 12 (*j*)) is preferable.

Vibration with an air hammer during welding has been used to some extent to relieve shrinkage stresses. It is evident that such a method would have to be controlled carefully to avoid excess movement of parts that might

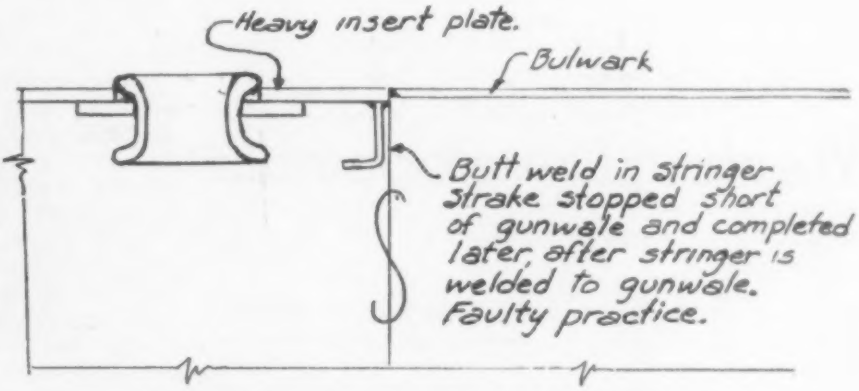

Heavy insert plate.
Bulwark
Butt weld in stringer strake stopped short of gunwale and completed later, after stringer is welded to gunwale. Faulty practice.

Fig. 17—Where There Are a Number of Details That Contribute to a Change in Stiffness of a Structure, Special Care Is Warranted to Avoid Local Stress Raisers or Defects, and Severe Restraint Against Shrinkage

cause rupture while the weld metal is hot. Vibration or peening immediately after welding while the weld is still hot and plastic, and immediately after the removal of this slag, is perhaps favored most.

Cold peening is no doubt actually used more than hot peening. It is well conceded that the root pass of a butt weld should not be peened for fear of rupturing the comparatively thin layer of metal. Some specifications prohibit peening of the last layer. The peening of this layer is usually not very effective in relieving shrinkage stress, anyway. Peening while the weld zone is cooling through the blue brittle range would seem to be dangerous. There is no doubt that any peening operations call for careful control and supervision. Conditions arise now and then where the use of peening seems indispensable. However, many of these cases, such as locked-up pick-up welds in gaps left in butt-welded seams, or at places where defects have been removed, can be avoided by careful control of fitting, welding procedure and sequence.

Combination of Unfavorable Conditions

A good example of an especially critical area, where particular care should be exercised to maintain proper welding procedure and sequence, is shown in Fig. 17. This area is along the gunwale, just forward of the house front, and in way of the corners of a hatch, which corners are reinforced by heavy insert plates. Stress concentrations are encouraged further, at the gunwale, by a rather abrupt local change in stiffness resulting from fitting a heavy insert in the bulwark to reinforce it at a mooring ring. Also a bracket is fitted and welded to the bulwark, the gunwale and the deck stringer plate, at the end of mooring ring insert plate. The welding is concentrated further by a deck butt which meets the sheer strake at this same location.

It is evident that a gap left unwelded at the outboard end of this deck butt, and welded later under restraint could very easily start a crack, and that if the longitudinal weld between the sheer strake and the deck stringer plate is carried past before the deck butt is completed, the restraint is very great. Also, a general area of high shrinkage may be set up if the deck butt is not back stepped or block welded.

Another example will illustrate a combination of unfavorable circumstances. In this one, which occurred at a bilge (Fig. 10) the floors of the double bottom had been cut loose from the bilge plate and heavy jacking and heating had been used to correct distortion that occurred during the laying up of the bilge plate to the ends of the floors, which were short of the molded lines. Poor fit-up at the butts in the bilge plate at the same general location contributed further to shrinkage stresses, at a place where the structure is quite stiff in all directions. As the plating cooled after the heating and jacking, a crack started near the *C-D* seam, some distance from the nearest butt, and the crack extended transversely across the *D*-strake and about one foot into the *C*-strake.

Conclusion

Most naval architects and shipbuilders are likely well aware of many of the fundamental principles that have been stated in this paper. However, welding is comparatively new to many individuals now engaged in welded construction. Those engaged in welded construction and design, other than in the field of marine construction, have had to be reminded of some of these features from time to time, to keep out of trouble.

It is, perhaps, unfortunate that some of the most important dictates of good welding practice often can be violated with impunity. When one "gets by with it," this tends to foster carelessness and disregard; and one can never predict whether trouble will result from such disregard. Fortunately, most cracks occur during construction. Experience indicates that residual stresses in any structure are ironed out and disappear during service, through the action of mechanical stress relief, and that there is no need for apprehension regarding the many welded ships that have already gone to sea.

One of the most important dictates of good control in welding is that adequate, written instructions, in sufficient detail and well illustrated, be provided to the welding supervisors by the welding foreman or superintendent to insure that they understand the welding procedures and sequences that are to be followed for each part of the ship.

At times like the present, when the services of inexperienced workmen must be utilized, when supervision is perhaps spread more thinly and speed of production is all important, the practicability of adequate control of welding might be questioned, if it were not for the mitigating circumstance that most of the welding does not affect the integrity of the structure as a whole. Also, most of the welding is done under such conditions that it is not difficult to control.

When one considers the tremendous volume of welded shipbuilding, the amount of trouble that has been experienced is relatively small. However, it is the duty of everyone engaged in the program to see that his part is done conscientiously.

1942 Electric Arc-Welding Developments

By R.F. Wyer*

IN 1942, as in 1941, there were more notable developments in the field of arc-welding operations than in new equipment or processes. Welding operators and supervisors deserve the praise of the industry for their almost incredibly effective performance in the battle of production.

The enormous expansion in the use of arc welding was aided in a large measure by the conservation activity of operating men which resulted in savings of electrode, time, electric power and equipment. These savings contributed to greater production of war tools just as surely as did expanded production facilities.

For example, many plants instituted intensive campaigns to reduce waste in electrode stubs, some adopting the plan of checking returned stubs for number and length before issuing new electrodes from the stock room. By this means, production per pound of electrode consumed was increased as much as 20%.

Stress was placed on the importance of good fit-up of joints in conserving deposited metal, and of proper adjustment of welding current and arc voltage to reduce

(*Continued on page 245*)

* Welding Engineer, General Electric Co.

Welding Metal Bed Springs*

By E. H. Atkinson†

THE object of this paper is to show how a manufacturer of metal beds and bed springs when deprived by war demands of his conventional hot-rolled steel shapes turned to an arc-welded design using shapes that he could obtain and thereby continued operation of his plant.

To appreciate the necessity of change let us look back to early 1941. Most of the world was at war or was preparing for war. With the lease-lend program in full swing, and with the National Defense program building army camps, warehouses and numerous defense industries, manufacturers of civilian goods made of steel began to feel the pinch of steel shortages during the middle of the first quarter of 1941. Before the end of the first quarter the steel mills were refusing orders for material not going into defense work. The last hot-rolled shapes this manufacturer received were ordered in February 1941 and were delivered in November 1941. So to continue the making of metal beds and springs it was necessary to change to some material that was obtainable.

The large steel mill which had been the sole source of supply for several years was by then engaged in rolling tin-plate stock and shell stock. At the end of the hot rolling of this stock, and before the cold rolling, the edges of the sheets had to be trimmed to cut away the edges which were laminated and checked, that is, the sheet had to be squared back to good solid stock perfect in structure. These trimmings were waste and had no value other than scrap to be remelted. The Government was and still is (May 1942) permitting the sale of this material for non-war work.

But to work this material into metal beds and springs, the customary method of manufacture had to be abandoned and a welded design was the answer to the problem.

In the summer of 1941 we began to run out of the regular angle-iron side rails for metal beds, and also the slatted steel bases for bed springs. So, we set out to make bed side rails and spring bases from the steel mill scrap.

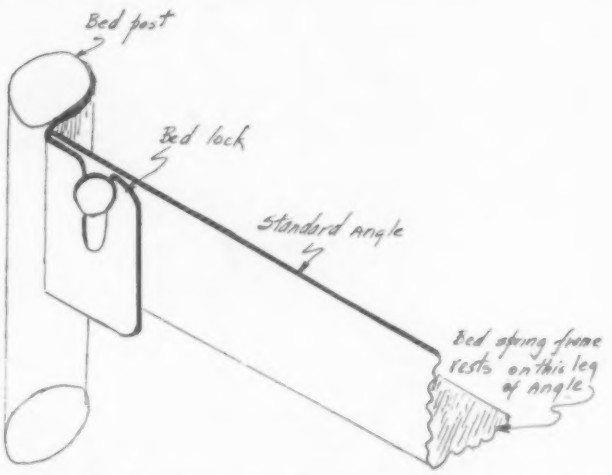


Fig. 2—Sketch Showing How Standard Side Rail Is Attached to Bed Lock

First let us consider the bed side rails. The bed side rail is that part of the bed which extends from the lock on the head of the bed to the lock on the foot of the bed. The two rails hold the head and foot of the bed in firm upright positions and also provides a support for the bed springs. The standard metal bed side rails are made of $1^1/_2$- × $2^3/_8$- × $^7/_{62}$-in. hot-rolled rail-grade steel angles. The short leg of the angle is notched on each end (to clear the rivets that hold the locks to the bed posts) and shoulder head rivets are riveted in the long leg of the angle near each end of the rail (shown in Fig. 1). These rivets fit into the bed locks on the head and foot posts as shown in Fig. 2.

The steel mills had the necessary equipment for cutting the trimmings to size and could then cold form them into various shapes. (These shapes limited, of course, to what equipment and rolls on hand as the mills could not increase their facilities for non-war work.) Had the trimmings been of sufficient thickness a $1^1/_2$- × $2^3/_8$-in. angle (the same leg dimensions as the standard bed rail) could have been formed and this substituted for the standard hot-rolled angle, but the available stock was so thin, an angle made of it did not have sufficient strength and would bend to the floor when used as a bed side rail. However, the steel mill did have rolls for shaping the metal in the shape shown in Fig. 3. Being a box section, this section had plenty of strength, but no place to fasten the necessary shoulder head rivet. To overcome this the rivet was riveted into a flat plate of the same scrap steel and electric welded to the box shape. To allow clearance for the rivets holding the lock to the post, the welded-on plate was allowed to project past the ends of the box section. One end of the completed rail is shown in Fig. 4.

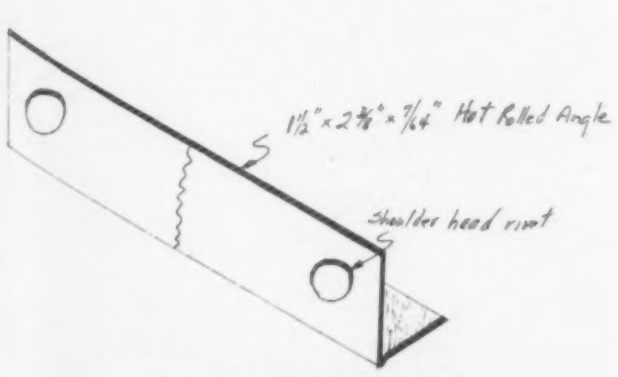


Fig. 1—Standard Bed Side Rail

* Third Prize Award paper in the F1 Furniture and Fixtures Division of the 1940–42 Industrial Progress Award Program sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland, Ohio. The award papers showed a possible Saving of $1,825,000, including 7,000,000 tons of steel and 153,000,000 man-hours of labor available by application of arc welding.

† Mechanical Engineer, Fulton Metal Bed Mfg. Co., Atlanta, Ga.

This new bed rail was approximately the same weight as the standard rail. It was nice looking, satisfying to the trade, and was stronger than the standard hot roll angle.

Before going into the cost let us consider the changes in the spring bases and carry the two costs along together.

The standard spring base for steel base coil springs (the same base is used throughout the entire country with only very minor changes) consists of a $1^1/_4$- × $1^1/_4$- × $^7/_{64}$-in. angle bent to form a continuous frame and usually resistance welded. For a standard double bed this frame is approximately 52 in. wide and 6 ft. long. Eight or nine 52-in. cross slats are riveted in forming a slatted steel base upon which to fasten the coils. The cross slats are usually $^1/_8$- × 1-in. hot-rolled rail-grade steel bands, twisted at each end so that the 1-in. side of the band is vertical. Figure 5 is a sketch of the standard frame.

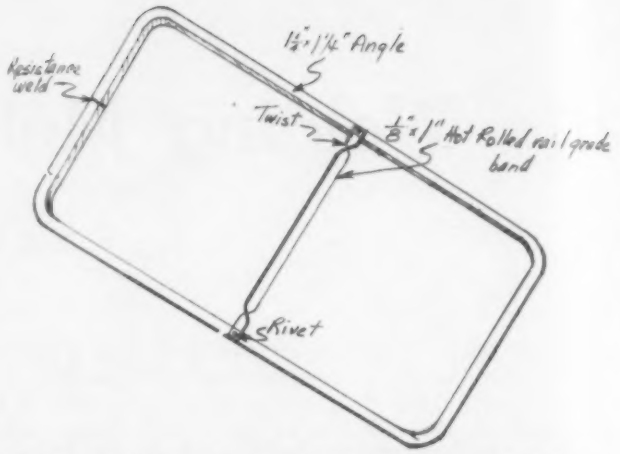


Fig. 5—Sketch Showing Standard Spring Frame with Only One of Eight or Nine Cross Slats

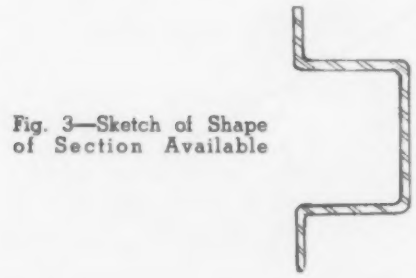


Fig. 3—Sketch of Shape of Section Available

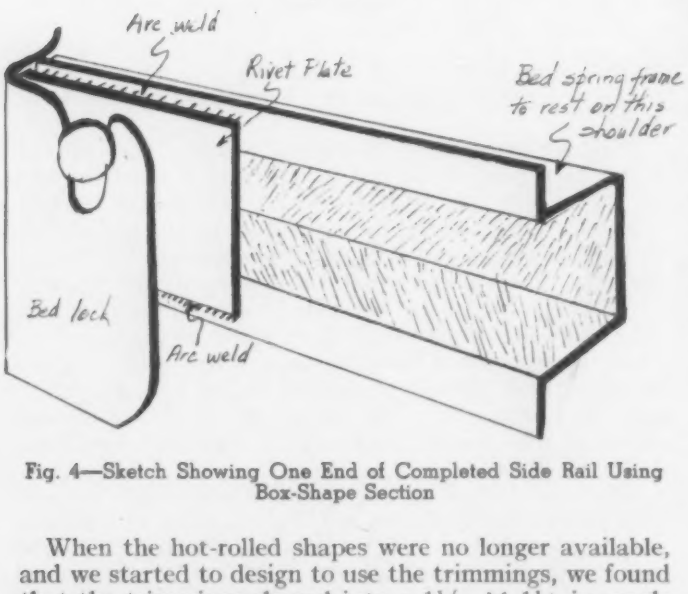


Fig. 4—Sketch Showing One End of Completed Side Rail Using Box-Shape Section

When the hot-rolled shapes were no longer available, and we started to design to use the trimmings, we found that the trimmings shaped into a $1^1/_4$- × $1^1/_4$-in. angle was sufficiently strong for the one-piece continuous frame, but that the same trimmings cut into strips 1 in. wide and used for cross slats like the standard $^1/_8$- × 1-in. hot-rolled bands did not have the necessary strength to resist bending. We had the trimmings shaped into $1^1/_4$- × $1^1/_4$-in. angles which, of course, would resist a large bending moment. These angles were then placed in crossways of the continuous frame and welded in place (see Fig. 6). (NOTE: a cross angle made of the trimmings 1 × $^1/_2$ in. would have had sufficient strength, but the steel mill only had rolls available for rolling angles $1^1/_4$ × $1^1/_4$ in. or larger. Conditions were such that you had to take what you could get and not what you wanted, or do without.)

The welded side rails and the welded spring bases were both stronger than the standard design which they replaced. However, this extra strength did not have any particular value to the manufacturer in that the standard design was strong enough for the purpose. In using angles of the trimmings in place of the regular flats in the spring bottoms, and in using the box section side rail in place of the regular angle, many more square inches of material was used in the welded design, but with this material only one-half as thick as the regular shapes, the total weight for the side rails were the same for both designs, while the spring base was slightly heavier than the standard. The scrap steel was a mild steel having a higher base price than rail grade steel and by the time the cost for cold forming these trimmings into the shapes necessary to get the required strength, the material costs for both items was higher than the standard. To cover the cost increases the manufacturer had to add 25 cents to the selling prices of the beds (20 cents additional material cost, 5 cents additional labor) and to the selling prices of springs 50 cents was added (40 cents additional material, 10 cents additional labor). Even with these increased prices, the manufacturer could not supply the demand in that competitive manufacturers were ceasing production for lack of their standard shapes. Of course, these welded designs will be aban-

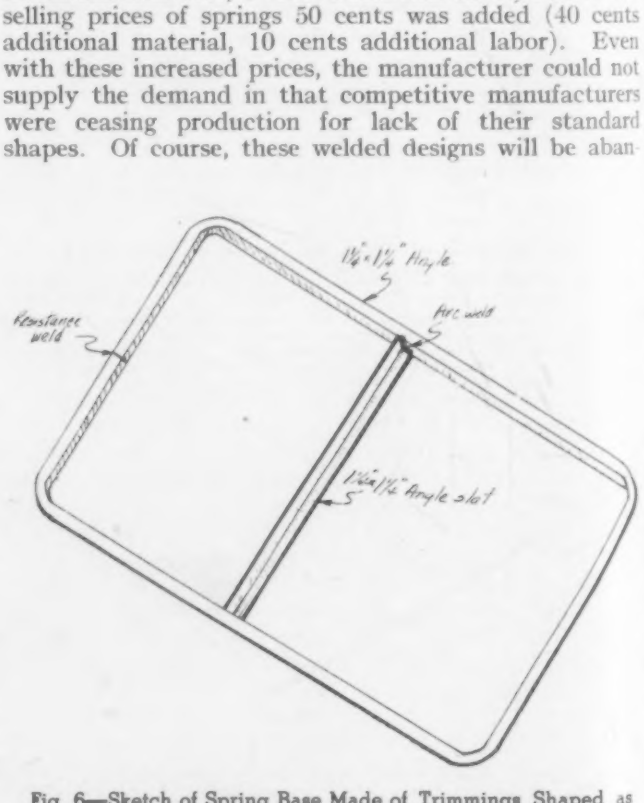


Fig. 6—Sketch of Spring Base Made of Trimmings Shaped as Angles. Sketch Shows Only One Angle Cross Slat Instead of Eight or Nine Required

doned when the steel mills resume normal production, but for the present it is letting this manufacturer continue production of a vitally necessary commodity that is going largely into defense centers for civilian workers. At the same time the manufacturer is keeping his plant in operation, keeping his old customers supplied with merchandise, and keeping his employees at work. There is no economy at 25¢ and 50¢ an item higher prices, but when the demand cannot be met even at the higher prices would there be economy in letting the plant and the employees stand idle for lack of standard steel shapes?

The changes to the two welded designs were carried on in the plant with the employees and equipment already on hand. Of course, jigs were made for both the side rails and the spring bases so that the individual pieces could quickly be placed in the proper positions and held there positioned for the easiest welding. Two jigs for each item were made so that one man could load and unload for the welder.

After getting our jigs made we were able to hold up normal production of 375 beds per week and 475 bed springs per week, and the steel mill accumulated much more trimmings than we could use.

All-Welded Liberty Ship Construction at Delta Shipbuilding Company, Inc., New Orleans, La.*

By E. B. Williams†

LAST June when I was asked to speak at this meeting I consented to do so, but was unable to name a definite subject. At that time the Delta Shipbuilding Company, in New Orleans, was just getting started. To be sure, we had built and delivered a couple of ships, the first two. But we were still feeling our way, developing an organization and working out many production problems. The picture today is quite different. We delivered a ship the other day in just seventy-one (71) days. This ship, our twenty-third (23rd) to date, was built in less than one-third (1/3) the time consumed on the first one.

It, therefore, led me to decide to discuss with you this evening a somewhat broader subject than the purely technical aspects of welded shipbuilding. Let me tell you briefly the story of Delta, the conception of the shipyard, its layout, the type of ship we are building, some of the problems, of which there have been many, and something of the welding of these ships.

About two years ago a group of people in New Orleans approached the government with a proposition of building a new shipyard at that city. This group, having organized the Louisiana Shipyards, Inc., convinced the Maritime Commission that New Orleans, with its mild climate, fairly adequate housing, abundant though inexperienced labor and an important seaport, was a good location. There remained, however, the problem of the design of the shipyard and the actual ship construction. About the same time The American Ship Building Company of this city was having a series of talks with the Commission to consider the possibility of building a shipyard on the coast and, to make a long story short, the two organizations were brought together by the Maritime Commission and The American Ship Building Company organized a wholly owned subsidiary, known as the Delta Shipbuilding Company, Inc. Louisiana would build the shipyard, with the aid of Delta's engineering advice and then Delta would take over the yard and build the ships.

I shall never forget my first visit to the shipyard site a year ago last April to witness the driving of the first piles. It was like sticking a fork into mashed potatoes. One light blow and the hammer rode the pile right down to the surface of the ground. My first reaction was that someone had made a terrible mistake and that we had better call the whole thing off before going any further. We were assured, however, that the engineers were well acquainted with the soil conditions and that there was no cause for alarm. For the information of those who have never been in this part of the country I might add, by way of explanation, that New Orleans is situated on the Mississippi River Delta. The land is very low, actually below the level of the river. There is a dry crust of heavy clay soil on the surface, below which is mud to a rather indeterminate depth. Some of the 60-ft. piles may have reached the bottom, finding a strata of sand or shell, but most of them carry their load by friction alone. The shipyard is supported by this piling, and they number something like 30,000. The building berths themselves and some of the buildings required a concrete slab over the piling to tie them together, since they are capable of a vertical load only.

The shipyard is located on the Industrial Canal, which connects the Mississippi River with Lake Pontchartrain. Lake Pontchartrain is connected with the Gulf of Mexico. and there is comparatively little fluctuation. At the river end of the canal there is a lock to take care of the variation in the level of the river, which at times is more than 20 ft. above the canal. The Industrial Canal is, of course, an artificial waterway and is of sufficient size to accommodate ordinary merchant ships. It was built to induce manufacturing plants to locate in New Orleans. The shipyard is arranged around two slips which were dredged at 45° from the direction of the canal. One slip is about 2000 ft. long by 200 ft. wide and the other about 1500 ft. by 210 ft. Approximately 150 acres comprise the shipyard. The building berths are arranged on either side of the longer slip, there being three (3) on one side and four (4) on the other. Another berth is around the corner on the face of the canal, making eight (8) ways in all. The vessels are launched sideways into the water.

The arrangement of the shipyard is unique in that each way is a complete unit. Material is fed into the Layout and Welded Assembly Shop from storage. Here it is flame-cut to size and with the required joint preparation, assembled into sections, welded and transferred alongside

* Presented at December 9th Meeting, Cleveland, Section, A.W.S.
† Vice-President, Delta Shipbuilding Company, Inc., New Orleans, La.

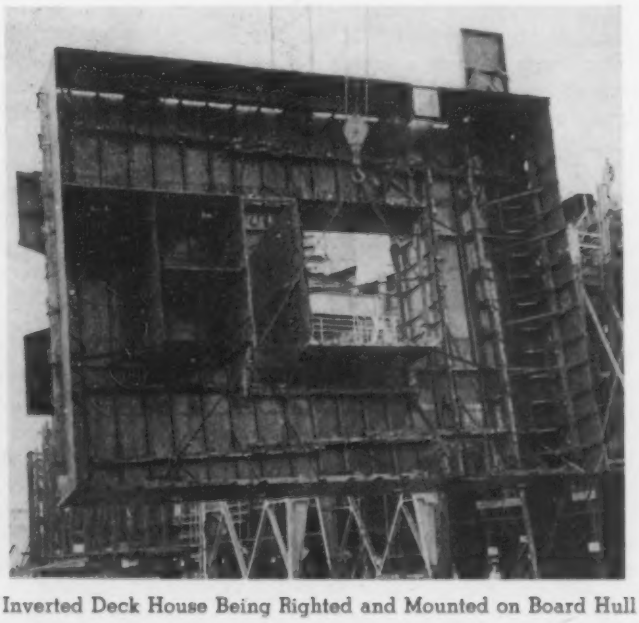
the ways to be later erected. At the head of each group of ways, one on each side of the slip, are two (2) Slab and Shipyard Machinery Buildings. These two (2) units supply all the ways with such material as may require rolling, or forming, or any furnace work. Certain small parts are also made in these shops. We also have a separate unit for making side-shell assemblies, which I will mention later. Another separate unit is for the construction of masts. Otherwise, practically everything feeds laterally through the Assembly Shop at each way.

This arrangement has a number of advantages. In the first place the shipyard could be reduced in size without materially affecting the efficiency. There are eight (8) units, any or all of which may be in operation. Another advantage of this arrangement is the competitive possibility, one shipway with another. We have a much coveted pennant, which moves from one shop to another, as recognition of a speed record. We have a similar pennant for the ways.

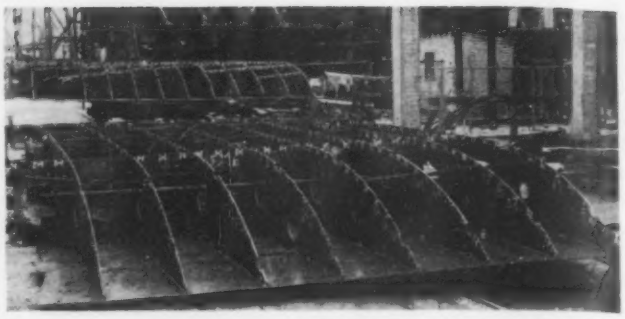
After the ships are launched they are moved to the other slip for completion. On one side of this slip we have a building 640 ft. long by 126 ft. wide. This building is the Machine Shop, Boiler Shop, Pipe Shop, Electric Shop and Joiner Shop, all under one roof. Alongside the slip is a gantry track with two (2) 50-ton gantry cranes. After launching, each ship is spotted along the gantry side in any one of three (3) positions for the installation of main engines and certain other heavy lifts. The ship then moves across the slip where there is locomotive crane service only, and finally finds its position at the canal entrance, where the dock trial is held. After the dock trial the ship proceeds on the sea trial, just prior to delivery.

The building berths are serviced by gantry cranes having a capacity of from 15 to 40 tons, depending upon the radius. This capacity is somewhat inadequate, but it was necessary for us to take what was available in the shortest time. There are about ten (10) miles of railroad track throughout the yard and we are well supplied with locomotive cranes, flat cars and locomotives. We also have hard surfaced roads and a fleet of trucks for the rapid dispatch of materials throughout the yard.

There are numerous storerooms, large and small, and a well-regulated system of handling ship materials. I won't go into such details at this meeting nor will I more than mention our two (2) cafeterias, two (2) large mess-



Inverted Deck House Being Righted and Mounted on Board Hull



Inverted Inner Bottom Sections Being Transferred to the Ways

halls, numerous food service stations, oxygen and acetylene pipe line service throughout the yard, hospital and first aid stations, locker-rooms, yard offices, miscellaneous shops, clock houses, fire station, police headquarters, etc. We have two (2) parking lots which would remind you of a Sunday double-header at the Municipal Stadium.

During the summer of 1941 we were confronted with almost every conceivable obstacle. It was necessary to make immediate decisions, and there were many substitutions due to the material situation. We find ourselves handicapped to some extent today, but the job is going ahead and there have been comparatively few regrets. When it was found impossible to obtain steel columns for the buildings we resorted to reinforced concrete. When fireproof construction materials became impossible to get we resorted to wood. On September 8th the first shop was completed, and with a simple ceremony we laid out and burned the first plate for ship construction. On October 1, 1941, we laid the keel of Hull No. 1. That ship was launched on the 28th of March, 1942, and was delivered on the 31st of May. As other units of the yard were completed, additional keels were laid and before the year is over we will have launched 30 ships, all but one or two of which will be delivered.

Due to conditions beyond our control we were about three (3) months late in getting the shipyard into operation. High water records were broken. We were deluged with rain. On several occasions the site was completely flooded. Contractors were late. The heat was intensive, not to mention the mosquitoes. Nevertheless, we did get started and our progress has been little short of phenomenal. When we started we had contracted to build twenty-five (25) ships by the middle of 1943. We will actually build thirty (30) ships by the end of 1942, and considering the progress on the ways this figure is nearer thirty-five (35) ships. I do not say this boastfully, except for the shipbuilding industry as a whole throughout the country. Other shipyards have done just as well under conditions just as bad. The performance of the shipbuilding industry throughout the country has been astonishing.

The nucleus of our organization was drawn from our several plants here on the Great Lakes. I could almost count them all on the fingers of my two hands. At the time we laid the first keel we had about 500 employees. By the end of the year we had about 2300. At the end of June, this year, our employment had risen to about 12,500 and at this date it is about 16,000. Most of these people came from the city of New Orleans, perhaps 15% came from the surrounding territory, and not more than 1%, and probably about $\frac{1}{2}$ of 1%, had had any previous shipbuilding experience. They were hired in the raw and trained as the work progressed. Shop No. 1 was really a training school and the employment in this shop was turned over again and again. State and Federal welding schools have been established throughout the state and the courses usually cover about 12 weeks' train-

ing, 6 hours per day. Graduates of these schools were put to work on tacking and unimportant welding to become familiar with our requirements. The American Bureau of Shipping cooperated most fully, by permitting non-certified welders to do unimportant work, and then permitted downhand, vertical and overhead welding as the men demonstrated their ability to perform. Later when experience had been gained the men were given the A.B.S. test and were eventually certified. The local schools were very helpful by establishing courses in ship-fitting, blueprint reading, etc., and the men took advantage of these courses during off hours. Tulane University also set up short courses in Naval Architecture and Marine Engineering. Later on our foreman conducted classes at the city schools. We also started a welding school to complete the primary training our welders had had.

The Engineering Department started from scratch along with the others. Some of the men had had college training and some had had engineering experience in other lines. Previous shipyard experience was practically lacking. However, under the excellent guidance of our Chief Engineer this department has developed to a point where I would stack it up against any other similar organization. Out of this department comes all planning, material requisitions, reporting, tests and trials and, of course, plans and plan alterations, of which there have been a great many. We maintain about thirty (30) blueprint files throughout the yard.

As to the ships themselves, the original design was quite simple, but the plans were most complete. The designers attempted to cover every detail and even went so far as to build a complete model of the machinery space, including the hull structure, units of machinery, pipe, fittings, valves, even down to lights and wiring, hand rails—everything, so that the plans would be complete, with bills of material down to the last nut and bolt. This was done in New York by the firm of Gibbs & Cox, Inc., Naval Architects and Marine Engineers. Several hundred men were employed on the design alone, and, in addition, they took off most of the material and placed orders with manufacturers throughout the country. Since then there have been many alterations. Crews quarters have been rearranged, deck houses have been enlarged, armament has been increased, many defense features have been added, life saving features have been extended and other alterations have been made as a result of the operating experience of the first few vessels. Many alterations have been made due to shortages in certain materials, requiring substitutions. In addition to all of these, there have been numerous changes initiated by ourselves in the interests of accelerated production and reduced labor hours.

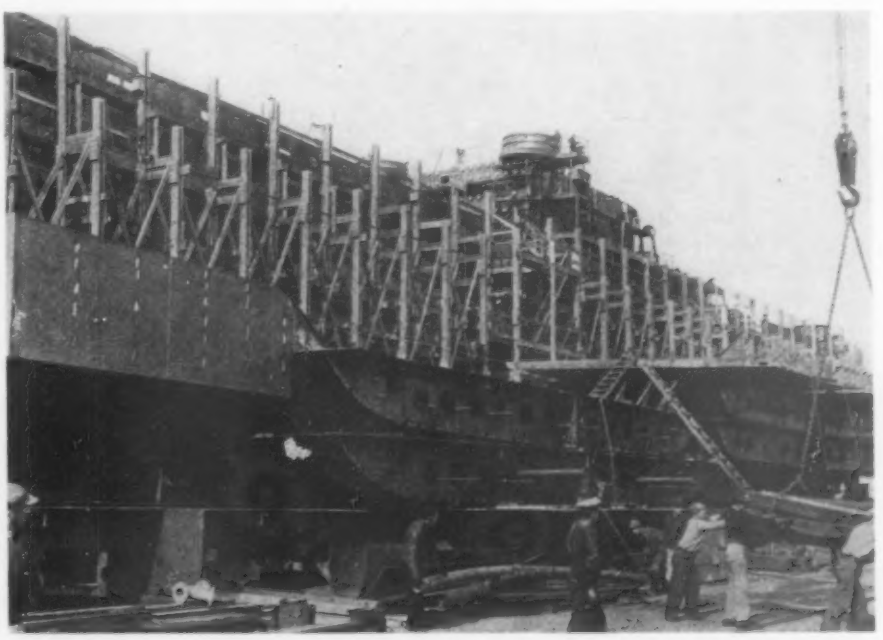
A Liberty ship has the following principal dimensions:

Length overall..... 441 ft. 6 in.
Length between perpendiculars.. 416 ft. 0 in.
Breadth molded..... 56 ft. $10^{3}/_{4}$ in.
Depth molded to upper deck.... 37 ft. 4 in.
Draft loaded..... 27 ft. 8 in.
Deadweight approximately..... 10,500 tons

The vessel has a raked stem and a cruiser stern and a continuous upper and second deck. There are five main cargo holds. Propulsion is by means of a single-screw, steam-reciprocating engine. Accommodations are provided for a normal crew of 49 men, plus a gun crew of about 30 men. The reciprocating engine was chosen as an emergency measure so as to employ relatively unused manufacturing facilities and not overburden the turbine builders.

In the hull design, considerable latitude was offered the several shipyards. Some elected to rivet the frames, others chose riveted seams. Some wanted riveted seams with welded frames. There were several combinations. We decided on a 100% welded ship. There are good reasons in some yards for a certain amount of riveting. Their equipment and organization are set up that way. With us, we could build the yard to *suit the ship* and there was no organization, so why complicate a practically all-welded hull with a little riveting?

Welding as applied to shipbuilding is still very new and the process will undoubtedly advance a great deal in the years to come. How far has it come to date? It has completely revolutionized the industry in a matter of less than ten years. Welded ships are stronger, lighter, faster and cheaper to build and maintain, and better in all respects. How far will it go? I don't know. Where a few years ago ships were all-riveted, they are now all-welded. A few yards are still riveting this or that, simply because they are better equipped for riveting and possibly reluctant to make the complete changeover, but the new yards are welding practically 100%. As a method there isn't much further to go. As to the means of using this method or tool or process, we have only started. We know this much: The many steel plates and shapes which make up a ship are more effectively joined together by welding than by riveting. That question has been fully answered and the matter closed. We also know enough about welding in ship construction to produce a good job. But there are many unanswered questions. Welded ship design is still somewhat crude and is restricted to a considerable extent by the necessity of using available structural shapes. Then there are questions of welding sequence, shrinkage and production methods. There is also the question of a.-c.



Inner Bottom and Other Sections Stored Alongside the Ways Ready for the Next Hull. Note That Inner Bottom Piping Is Already Installed

One of the Many Broadside Launchings at the Delta Shipbuilding Co., Inc. Vessels Are Ready for Service About Fifteen (15) Days After Launching

power *vs.* d.-c., automatic welding *vs.* manual, this type of machine and that.

Yes, there are many unanswered questions, and for the duration they may remain unanswered. In times like these we must carefully choose our course and then hold to it as closely as possible. But with so tremendous a program we can't help but learn and advance even though we are thinking mainly in terms of production.

At this point I should like to make a statement which has been on my mind for a long time, and which, comparatively, few people realize. A year ago many of the shipyards were just getting started, and they were faced with a construction program in merchant shipping such as the world had never known. The Government wanted 8,000,000 tons of new construction in 1942 and 16,000,000 tons in 1943. The first year is almost over and as Admiral Howard L. Vickery has recently stated, the goal will be reached. Without close cooperation between the shipyards and the Maritime Commission the job could never have been done. Without aggressive and wise management on the part of the shipyards we would have been unsuccessful. Without the splendid spirit and determination on the part of the men building the ships we would have missed the goal. There has been another factor, however, in the success of the program which, to my mind, prepared the ground work so that the rest of us could go ahead. Long before the war, and, before any of us had any conception of what was coming, the American Bureau of Shipping gave its approval to the *all-welded* ship. The very problems of welded construction made prefabrication necessary and, as we all know, prefabrication has been the secret of today's production records. The foresightedness and wise guidance of the Bureau stems mainly from our own First Vice-President of this Society and Chairman of the Committee on Welding in Marine Construction, Mr. David Arnott, who, of course, was backed by the President and other executive officers of the American Bureau, and supported by his able Assistant, Mr. J. Lyell Wilson, and his staff. Mr. Arnott has recently presented a paper before The Society of Naval Architects and Marine Engineers at its annual meeting in New York on the 13th of November, this year. This paper, "Some Observations on Ship Welding,"* covers in an excellent manner the progress of the year in ship welding throughout the country. I recommend this paper to each of you, whether you have any particular interest in shipbuilding or not. It is not within my comprehension to amplify Mr. Arnott's paper, but merely to bring you a little closer, perhaps, to ship welding, by confining my remarks to our experience at the Delta yard.

To get back to our subject, Delta elected to weld 100%. The shell plating was first welded in place using the customary shift of butts. Channel frames were used and holes were punched at about 18-in. centers for bolting. These holes were later plug-welded. After the first round of ships was built, it was decided to line up the three strakes of side shell plating so that the butts would come together, and to prefabricate the panels 30 ft. long with the side frames attached thereto. We still retain the shell flange of the frames, which are continuously welded heel and toe. The two shell seams in the assembly are Unionmelt welded. The service holes have, of course, disappeared.

There have been numerous changes in the welding details which have been brought about by our experience. These changes have been made in the interest of increased production and to use automatic welding to the greatest advantage. In deciding on any welding detail there are several important factors to be considered. First, there is the joint preparation itself, and then the fit-up. Then we have the question of whether it can be automatically welded and finally there is the question of time and labor hours. Any one of these factors might upset all the others. To cite an example let us take the seams and butts of the bottom shell. In our yard these plates are assembled individually on the ways, tacked together and then welded. We went through somewhat of an evolution in developing the welding detail. The obvious joint would be a double "V" manually welded and, of course, using a minimum amount of weld metal. After trying several types of joint we finally adopted a single "V" with the thickness of the plate at the root about $^1/_{16}$ in. This is a 45° "V" so that a manual bead using speed rod may first be laid in the root. This bead is then

* Published in the Feb., 1943 issue of THE WELDING JOURNAL.

followed up by a single Unionmelt pass. After this is completed the root is chipped out from below and there are one or two overhead manual passes.

I mention this example merely to point out that the designer of welded construction must temper his design with considerations involving time, labor hours and construction problems generally. In welded construction it is necessary for him to get into the job from all angles. Welded construction should start with the design, but that design cannot become stereotyped as in the case of riveted construction.

The welding sequence being followed at Delta is, in general, similar to that followed in other shipyards. Starting with the bottom plating we weld port and starboard seams together, then tack the butts and additional seams, working from amidships outward and fore and aft simultaneously. We do not cross a butt until the butt itself has been welded, and we are always careful to weld both sides at the same time.

After the bottom shell has been welded amidships, inner bottom sections are put in place, regulated and welded. Each inner bottom section is a unit the full width of the ship and about 20 ft. in length. It is prefabricated in the shop on the welding grids. The inverted plates are Unionmelt welded, and the vertical floors and longitudinals are fitted and welded thereto. The operation involves horizontal, vertical and downhand welding, and machine welding, but no overhead. As each section is assembled the inner bottom piping is installed. Finally the section is turned right side up and another machine weld is made on the plate seams. Following the inner bottom, bulkheads and side shell sections are erected. Deck sections are then fitted and gradually the vessel takes shape. The welding follows erection as closely as possible, gradually terminating at the ends of the vessel, which are welded before the stern frame is bored for the tail shaft.

To give you a better idea of the construction of one of these ships let me trace the erection week by week from the day the keel is laid. During the *first week* about 1200 tons are erected, including the bottom plating, inner bottom sections, bulkheads 68, 88, 108 and 116, settling tanks, bilge plates, second deck and side shell from about frame 68 to 116 and also the shaft tunnel. During the *second week* about 400 tons are added, including second deck, additional bulkheads, shell panels and stern frame. Another 400 tons are added during the *third week*, including the upper shell, upper deck amidships, hatch coamings 2, 3 and 4, bow sections, boilers and some auxiliaries. During the *fourth week* the remaining upper shell is fitted and decks at the ends, the stern section and some of the deck houses. During the *fifth week* erection is practically completed, including deck houses which are, of course, constructed on the grids. During the *sixth week* deck machinery, fittings, bulwarks and miscellaneous items are installed, and the hull is prepared for launching. Owing to the limited crane capacity, the main engine cannot be installed on the ways. We do, however, install most of the auxiliaries. Plastic armor, magnesite flooring and other items are installed before launching.

According to our present schedule, which will probably be reduced before long, a ship is ready for launching in 44 days. In another 15 days the ship is delivered, making a total of 59 days. In the outfitting basin we install the main engine, shafting, etc. Welding is also completed here, and any necessary shrinking, also joiner work and general outfitting. There is a dock trail at the yard and on the following day a sea trail.

At the present time about 40% of the welding on one of our ships is done in the shops or on outside welding grids. This percentage will, undoubtedly, increase until probably more than half the welding will be completed away from the ways. The total welding on any one ship amounts to approximately 207,000 ft., of which about 41,500 ft. are done by the Unionmelt process. The above figures are approximate only and, of course, represent completed welds, and not the welding of individual passes.

My few remarks this evening have not been very technical, but for the past year and a half I have been getting farther and farther away from the technical side of welding. In fact, I am becoming somewhat fearful of being able to even discuss it intelligently. If any of you have been expecting a technical discourse I am sorry that you have been disappointed. We are not all of us shipbuilders here tonight, but beyond any doubt we are all tied into this war effort in one way or another. This organization meets together periodically to listen to the experiences of others and to discuss freely all welding matters. If I may emphasize any one thought to leave with you it is this: Welding is a proposition which requires teamwork. The design is one important factor, the actual welding is another of equal importance. Most important of all is that both of these factors get together before the weld is made.

Since this paper was written there has been a further reduction in the time required to construct the hulls on the ways ready for launching. We are now averaging 40 days on the ways and another 4 or 5 days will soon be saved. Material shortages are now interfering with construction, but it is hoped that this bottleneck will soon be eliminated. With materials available in ample time to permit proper scheduling of the work, the 30-day ship is well within reach.

1942 Electric Arc-Welding Developments

(*Continued from page 238*)

spatter loss. The skill and cooperation of welding operators in avoiding oversized fillets and excessive reinforcement helped still further in saving electrodes.

Savings in time were accomplished by the use of larger electrodes where practical; in many cases such use of larger electrodes resulted in an increase in production per hour of as much as 33%. This trend also helped to alleviate the electrode shortage by making possible the production of greater tonnages of electrodes with existing production facilities. Higher duty factors through the reduction of electrode-changing time further contributed to increased production.

Power was conserved through the more efficient use of welding machines and through the greatly increased use of a.-c. welders with a consequent reduction not only in the energy consumed but in the copper wire and other facilities required to deliver the energy. The latter reduction was augmented by improved arc-welding load power factor through the use of capacitors built in or attached to arc-welding equipment. A further part in conservation was played by increased stress on the maintenance of arc-welding equipment and accesories.

Among the outstanding developments in 1942 were the employment of women as arc-welding operators and the use of improved methods for the mass training of enormous numbers of new operators. The latter effort was marked not only by the establishment of fully equipped welding schools by individual fabricators, but

(*Continued on page 261*)

Panel Discussion—War Production Committee, Philadelphia Section, American Welding Society*

Reported by H. Carey Boss†

Conservation of Electrodes, Oxygen, Acetylene and Power in Welding

THE meeting was opened by the chairman, Mr. Harry W. Pierce, New York Shipbuilding Corp., at 8:00 P.M. with a brief review of the purpose of this panel which is intended to offer as much information as possible to the foremen and supervisors of small shops and plants to whom the most current developments in engineering are not immediately accessible and to find out whether or not such discussions can be of sufficient interest to warrant additional panels of a similar nature. At the same time, the chairman announced that inasmuch as this discussion was being held on the night of the AMERICAN WELDING SOCIETY'S usual meeting, the January meeting on "Welding in Aircraft Construction" has been postponed until later in the spring.

With this introduction, the discussion proceeded in the following manner with each of the Panel Members speaking briefly on the topic assigned, primarily to arouse general discussion from the floor in the form of questions or suggestions which may be of general interest.

Mr. K. W. Ostrom, Arcos Corp., recently with Welding Section, WPB, "Facts and Figures on Welding Materials."

The production of arc-welding electrodes reached about 50,000,000 lb. during the month of October 1942. This is expected to reach an average monthly figure of 100,000,000 during the current year. The WPB is basing its figures on electrode requirements upon the amount of steel manufactured and available for welding.

The WPB has made a survey of resistance-welding machines of standard designs and models and, if contacted, can ordinarily provide those desiring such equipment with standard used machines. New machines are being produced at a good rate but the equipment necessary for control is momentarily holding up the output.

Mr. G. R. Johnson, Manager, Philadelphia District, Lincoln Electric Co., "Electrode Conservation."

There are two basic ideas to be followed in arriving at the necessary economy in welding. These are: (1) design, and (2) procedure. Factors entering into design include selection of proper type of joint, type of electrode, position of welding, and use of largest size electrodes possible. The principal bottleneck in the manufacture of electrodes is the coating process rather than the actual metal electrode itself. Accordingly, twice as much weight in electrodes may be used by employing $^1/_4$ in. size instead of $^1/_8$ in. since the number of electrodes in 2 tons of the former size is the same as in 1 ton of the $^1/_8$ in., thus requiring the same amount of time and equipment in coating operations.

Mr. H. R. Salisbury, Manager, Philadelphia District, Air Reduction Sales Co., "Reduction of Waste of Oxygen and Acetylene."

In supplying gases, there are two main considerations—reducing and compressing the gas, and obtaining cylinders or other containers. The latter is of more importance at the moment since the Army and Navy are taking the full output of cylinder manufacturing facilities. As an example which shows the need for increased volume of handling facilities, the New York Shipbuilding Corporation's consumption has increased 700% in the past $2^1/_2$ yrs. In an effort to keep plants operating without interruption, considerable handling of gases from one place of comparative plenty to others of scarcity has been necessitated, in some cases involving transportation over a distance as great as 1000 miles.

Turnover in cylinders has been reduced 55% but even so, additional means of conservation are necessary. In an effort to accomplish this and make the present supply of containers serve our purpose until more are available, the following steps were suggested:

1. Take all empty cylinders to loading points immediately—do not allow to lie around and become mislaid.
2. On jobs where very little gas is consumed, use small cylinders and replace them more frequently, leaving the larger ones for jobs where they are absolutely necessary.
3. Cut down the number of cylinders on manifolds to the minimum actually required.

Mr. J. D. Bert, welding engineer, Navy Yard, Philadelphia, Pa., "Plant Methods to Conserve Welding Materials."

Electrodes are being conserved by policing their distribution and requiring each operator to burn the electrode down to the shortest possible stub.

Welding power can be conserved by installing resistor boxes on small 200- and 300-amp. welding machines, thus making it possible for more than one man to work from a single-operator machine.

Mr. O. C. Frederick, welding engineer, West Philadelphia Plant, General Electric Co., "Plant Methods to Conserve Welding Materials."

In a survey of the work going through the plant, it was observed that, as a result of striving for first quality work where it was required, all work, regardless of use, was being done with the same quality workmanship. By dividing the work into three classes, according to quality of work actually required, it was possible to work out the best consumption figures on gas for the particular job, thus speeding up work on numerous items, cutting down on gas consumed, and accomplishing considerable economy on these items.

By installing two-gage regulation for oxygen and acetylene, it is now possible to empty a bottle of all usable gas, thus extending the period considerably on each change of cylinders.

In order to conserve copper, a considerable cut has been made in size of wire on small machines. At the same time, rubber can be conserved by using a stiff cable for a good part of the secondary lead and using the highly flexible cable only near the work.

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* Held Monday Evening, January 18, 1943, in the Crystal Room, Broadwood Hotel, Philadelphia, Pa.

† Secretary, Philadelphia Section, A.W.S.

Upon the request of the chairman, numerous questions were asked from the floor, as well as suggestions from both the Panel and the floor. These are enumerated below in question and answer form.

Question or Topic	*Answer and Discussion*
Bare electrode for training operators	Origin of the bare electrodes for training came when we did not have enough coated electrodes. The schools had to take what they could get or do without entirely. With careful instruction, Mr. Ostrom felt that the operator could be given the proper changeover from bare to coated electrodes, after training for a period of approximately one week, without any serious loss of time or efficiency. During this first week of training, the bare electrode could be used to train the operators on machine setup, definition of voltage and amperage, how to control the arc, proper weld size and proper manipulation.
Bare electrodes for miscellaneous jobs in actual construction	Mr. Jackson stated that bare electrodes are now recommended for use on certain structures by the American Bureau of Shipping. These include upper sections as well as other unimportant (as far as strength is concerned) sections of a ship. One principal disadvantage expressed in this respect is the fact that it would require different current settings and the bare electrodes require d.-c. current. Other purposes for which bare rods are being successfully used include tank grooves, ladders and tank tops.
Use of rejected wire for training purposes	Wire rejected because of defects in the coating process can be used in training operators. This amounts in some cases to as high as 3%. While the wire with defective coating is naturally not so good as that with good quality coating, it can be used with very little difficulty in training and manufacturers are now sorting and making this material available in an effort to place as much coated wire as possible at the disposal of the producers of essential materials.
"Specialized" division of work and training	With the present shortage of welding operators and the need for as short a period of training for new men as possible being essential, it has been found that by training each man for a particular type of work, eliminating all others in the initial training period, a first quality operator can be produced for that job in a considerably shorter period than previously. If the man desires to further his training in other fields of welding, he may easily do this while actually producing the work for which he has been trained.
Reduction of stub loss	Numerous methods have been tried in an effort to reduce stub loss but the only effective method to date has been the policing of wire to the men. By providing each operator with a box and a specified quantity of electrodes, the wire tender can count the stubs returned and turn any that are not sufficiently used back to the operator. Some plants have actually reduced stub loss to 1 in. but $2^1/_2$ in. is a good average if obtained. This, of course, is dependent upon the size of electrode and the type and position of the work being performed. It was pointed out that a number of electrode holders now on the market are not conducive to economy in this respect since the method of gripping the electrode obstructs operations in close quarters. At least one holder has been designed which grips only $^3/_4$ in. of the electrode as against the usual $1^1/_2$ in. A definite attempt is being made to educate the operators against the practice of bending an electrode since this destroys the coating for a considerable length of the electrode and automatically increases waste. Posters have been placed in plants pointing out the fallacy of ideas concerning this unnecessary bending. With the addition of great numbers of newly trained operators, it is felt that a large portion of this is being eliminated since it is something that had developed with the older welders and now practically all holders are designed to clamp the electrode in a number of angles in order to facilitate welding in confined areas.
Conservation of welding tongs and leads	By means of posters, placards and constant reprimanding by supervision, an honest effort is being made to lengthen the life of welding tongs by preventing their use as hammers, pry bars, etc. They are designed for a specific purpose and, if used properly, will last indefinitely.
Conservation of oxygen and acetylene	Numerous suggestions were offered for the conservation of gases, including: 1. Cut off torch while setting up additional work. Do not lay the torch down in a burning condition. 2. Remember, oxygen is "OXYGEN," not "AIR," and should not be used for odd jobs such as to clean the work, cool the operator, etc.
Conservation of welding electrodes	By substituting resistance welding on work requiring small-diam. electrodes, considerable material can be saved as well as making use of many advantages which resistance welding offers in this particular type of work. It was noted that in one plant, as much as 500,000 lb. of electrodes have been saved in a period of one year by this means. It was felt by some that by increasing the length of the electrode and, in some cases, using center grip, the stub loss could be considerably reduced. However, this has a number of disadvantages: 1. In using longer electrodes, the heat produced is so cumulative by the time the normal length has been used that the coating is damaged on the balance which actually increases loss. 2. It is impossible to use longer electrodes in certain cases due to restricted space conditions. 3. The longer electrodes also tend to create an extravagant attitude on the part of the operator. Too frequently, where the normal length of electrode is sufficient to complete the increment or job, the extra length is discarded in favor of a new electrode.

Cards requesting those present to comment on whether or not they felt that the form of discussion was of material value and worth continuing in the future were distributed and, out of an approximate attendance of 200, 73 were turned in at the close of the meeting, 68 of which commented positively in favor of additional panel discussions.

The meeting was adjourned at 10:15 P.M.

How to Recondition Worn Pump Shafts and Rods*

By Welding

THE method which produces a built-up rod or shaft with the highest strength, toughness and stiffness is the welding method. It is usually the most convenient method also, for any maintenance shop with electric-welding equipment can recondition worn shafts and rods by following the procedure outlined below.

Preparation for Welding

As in any welding job, the surfaces to be built up must be clean. Foreign materials, such as grease or particles of packing, should be removed by rough machining, grinding, filing or by wire-brushing.

Building Up by Welding

The best electrode position for downhand welding is at an incline of about 20° from the vertical, ahead of the puddle. It is the most suitable position for controlling the molten flux and eliminating slag trapping. A short, 24–27-v. arc should be maintained during welding. The recommended electrode sizes and current settings for different sizes of shafts and rods are given in the table below.

Recommended Electrode Sizes and Current Settings for Building Up Monel Shafts by Welding

Shaft Diam., In.	130× Monel Electrode Diam., In.	Current Range, Amp.
1/2	0.075–3/32	45–60
3/4	3/32 or 1/8	45–60 or 60–95
1	1/8	60–95
1 1/2 or larger	5/32	80–150

NOTE: Where large shafts must be heavily built up to fit oversize bearings, the welds may be laid with 3/16-in. electrodes at 140 to 190 amp. or with 1/4-in. electrodes at 170 to 260 amp. More care must be taken with these larger electrodes, however, to equalize the heat input at all points on the shaft.

The chief precaution in building up a worn shaft by welding is to prevent warpage. This can be controlled by keeping the welding heat low and by laying down the welding bead longitudinally along the shaft as illustrated here.

In building up shafts smaller than 2-in. diam. the beads are laid down in a sequence alternating from one side to the other side diametrically opposite. Each weld should be cleaned of flux and wire-brushed before the adjacent bead is laid.

Fig. 1—Sequence for Laying Down Welding Beads on Shafts Two Inches in Diameter and Smaller

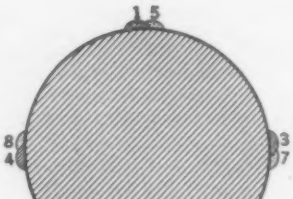


Fig. 2—Sequence for Laying Down Welding Beads on Shafts Larger Than Two Inches in Diameter

In building up shafts larger than 2-in. diam., the beads are laid down according to the sequence shown in Fig. 2.

These procedures tend to equalize the effects of heating and cooling, keeping the shaft straight. They are followed through, keeping the size of the beads and the welding speed uniform, until the worn section is completely built up to the thickness required for finishing to the final dimensions.

Finishing to Size

The completed weld build-up is clean and solid, with close-knit and uniform rows of beads overlapping each other. After being built up, the shaft is machined and finished to its final dimensions.

By Metal Spraying

Probably the simplest and most widely used method for building up worn shafts of all sizes is the metal

Reconditioning a Shaft by Building Up the Worn Section with a Weld Deposit. The Beads Are Laid Lengthwise and Diametrically Opposite

* Reprinted through courtesy of Mechanical Topics, International Nickel Co.

Close-up of Shaft Showing How the Shaft Has Been Built Up by Welding

spraying method. This use represents an especially suitable application for metallizing because of the peculiar, porous structure of sprayed metal coatings.

For some purposes, this porosity is a limitation on the use of sprayed metals because it weakens the tensile strength and toughness of the coating. Consequently, metal spraying cannot strengthen and stiffen a built-up section as welding does. When worn shafts are built up by the metallizing method, however, the porous structure of sprayed metals provides one definite advantage.

This advantage is the exceptionally good bearing qualities of sprayed metal coatings The pores fill up with lubricant and exude it over the bearing surface when the shaft is in service. The effect of this oil film in minimizing friction is the reason for the remarkably long service records reported for sprayed metal-wearing surfaces.

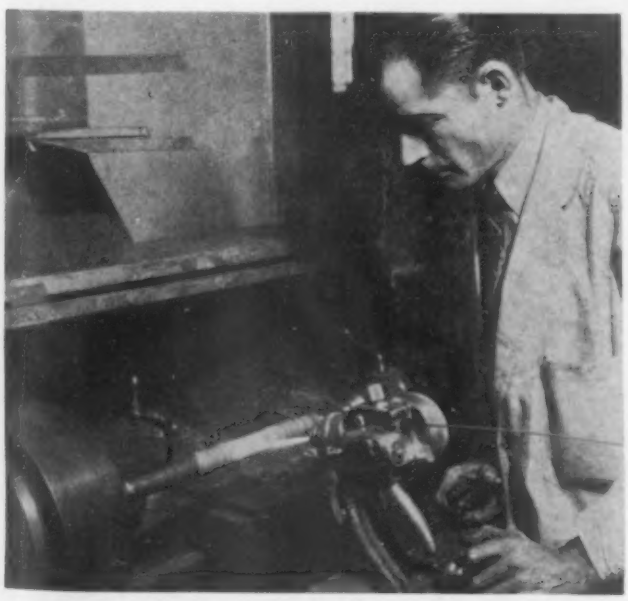
Preparation for Metal Spraying

The success of any metal spraying depends on securing a good bond between the base metal and the sprayed metal. Since the sprayed metal particles chill too rapidly to fuse with the base metal, the coating must be keyed or dovetailed into the shaft to provide a mechanical anchorage.

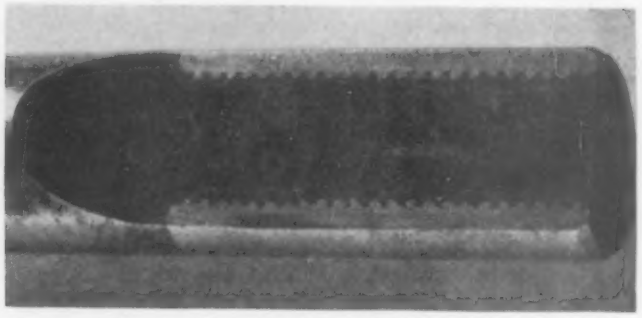
First, the worn section is machined to clean up the worn surface and provide for the proper thickness of metallized coating. (Machining should be done dry—the metal surface must be kept perfectly clean to produce a good bond.)

Second, the machined surface is grooved or cut with a rough thread of approximately 24 to the inch.

Third, the grooved ridges are roughened and spread to form dovetail keys by running a rotary shaft preparing tool across the machined section. (This set-up is shown above with the tool in the tool post.)



Showing the Operation of Metallizing a Shaft to Build Up the Diameter



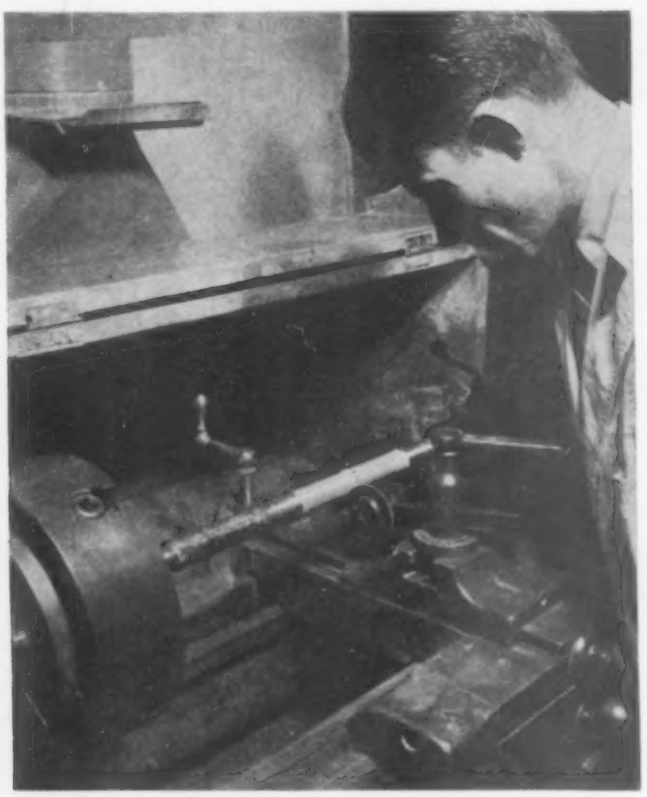
Close-up Showing How Metallized Metal Adheres to the Base Metal When the Surface Is Properly Prepared

Building Up by Metallizing

Since any oil, dust or even fingerprints on the prepared surface can impair the bond, it is advisable to metallize a shaft soon after the preparation is finished. The first few passes are made with the gun held at an angle to the work, alternately spraying from each side, in order to deposit the sprayed Monel underneath the dovetails. Then the gun is mounted in the tool post holder with the nozzle 6 in. from the work, and the balance of the Monel coating is applied at a 90° angle to the work.

Finishing to Size

The built-up coating is tightly anchored to the shaft by the dovetail keys as shown by this cross section, and the tensile strength of the bond is practically equal to the strength of the coating. After being built up, the sprayed section may be finished to size by grinding or machining and lapping with 00 emery.



Set-up Showing Surface of the Shaft Being Prepared for Metallizing. After a Rough Thread (24 to the Inch) Has Been Cut to Prepare the Surface, the Apex of the Thread Is Broken Down by a Kurling Tool Called a Shaft Preparation Tool (Shown in Tool Holder)

Arc Electrode Usage to Increase War Effort

By C. J. Holslag*

ARC welding covered electrodes are one of the bottlenecks of our country's production and the day of mystery as to what is in those coverings is about over so we are going to include in this article what we have learned about covered electrodes.

Before referring to the list enclosed, which has been collected and compiled by our Mr. Sternberg, the historical summary given below will furnish the necessary background.

It is hoped that this article will correct a trend of certain inspection departments in requiring chipping of slags.

Specifications require slag removal. Most modern electrodes are friable enough so that no chipping is necessary. Just rubbing the bare end of the next electrode will usually clear the path for the next layer.

The old-fashioned covered electrodes had such a thick and tenacious covering that they had to be chipped off. Not only did you have to chip off between layers, but you had to chip off if you broke the arc and started again. This type of covering was insulating, glass-like and very careful procedure had to be used to keep the slag from getting around in front of the arc and putting out the arc. Modern friable covered electrodes, however, are much easier to run, and they do not have to be chipped.

Approximately all U. S. modern electrodes are this kind and where they are not, a good hot arc, which is the best way to get production and also the way to get best results, would melt away the slag as the arc proceeds without any danger of getting slag in the weld or any danger of porosity. In fact, in all of the tests that I have ever made, the hotter the arc, the more fluid the slag runs, the better the weld results.

Another thing that we would like to bring out is the use of dipped electrodes. The A.W.S.-A.S.T.M. quite rightly do not limit the method of manufacture of the heavily coated rods in their specifications so long as they meet certain test results. Good grades of dipped electrodes will meet these specifications.

* Electric Arc, Inc., Newark, N. J.

Alphabetical List of Ingredients of Welding Rod Coatings, and Their Possible Functions

INGREDIENT	*FUNCTION*
Alpha cellulose (See also Carbonaceous Material, Cotton and Rayon, Paper, Paper Pulp, Wood flour	Burns, forming carbon oxides, thus consuming oxygen which is kept away from the weld metal, the gases formed also "blanketing" the fused weld metal. Before burning, provides support for the coating, finally contributing to formation of a shield during welding.
Aluminum Monohydroxide (Diaspore) Aluminum Oxide (Alumina) Aluminum-bearing silicates	To impart friability and ease of removal of the slag in which titanium dioxide and sodium silicate have also entered. Also to control melting point and consistency of the slag.
Asbestine (Magnesium Silicate)	To insulate and protect the weld by supplying magnesium silicate to act as a carrier or diluent for titanium dioxide, contributing to uniformity, continuity and removability of the slag. Because of fibrous nature of asbestos and asbestine to strengthen the coating.
Barium Carbonate	On decomposition at the welding temperature to furnish carbon dioxide for protection against oxidation, and to impart brittleness to the slag.
Borax	As adhesive where a ceramic coating is applied to the rod.
Calcium Carbonate	To furnish carbon dioxide to blanket the weld, and to impart desirable properties to the slag in order to improve the penetrating properties of the arc.
Calcium Chloride—Calcium Fluoride	To dilute elemental titanium and to increase speed of welding.
Calcium Hydroxide	To serve as a lubricant in the drawing operation for application of the coating by extrusion.
Calcium Molybdate	To transfer molybdenum from the coating to the fused metal, where this element is needed in definite proportion in the finished weld.
Calcium Oxide (Lime)	To adjust basicity of slag usually along with silica, and to serve as a diluent.
Calcium Silicates (Usually introduced as part of complex silicates)	To regulate properties of the slag such as melting point, consistency, friability, etc., especially where the silicate contains appreciable aluminum.
Carbon Carbonaceous Material	As an alloying element to be transferred from coating to weld metal. To burn to form carbon oxides to blanket the weld and deoxidize. In wrappings either around an inner mineral coating, or as an inner coating with mineral binder, or as an inner wrapper impregnated with mineral coating to perform the above mentioned deoxidizing function, and/or strengthen the coating often to form a shield.
Cellulosic Material	See above under Carbonaceous Material.
Cerium	Deoxidizer.
Clay	To furnish silicates for the slag and in some cases to dilute elemental titanium where used as ferro-titanium or manganese-titanium. As fire clay to provide insulation and regulate boiling point of slag.

Clay, silicious and titaniferous	To form slag and at same time furnish titanium and manganese.
China Clay	To raise melting point of slag when used in conjunction with silica, titanium compounds and other clays under restricted limits.
Cotton and Rayon	Utilized as fibers for wrapper as described under CARBONACEOUS MATERIAL.
CHROMIUM	To transfer chromium from coating to weld metal: in early usage believed to be deoxidizer.
Coal, high volatile	See CARBONACEOUS MATERIAL.
Dead Burned Slag	To quiet the reaction and dilute the flux dry
Ethyl Orthosilicate	Binder.
Feldspar	To provide silica content of slag; to contribute to stabilization of arc.
Ferro-chrome Ferro-chromium	To transfer chromium from coating to weld metal during welding, minimizing oxidation; to deoxidize.
Ferro-manganese	To transfer manganese from coating to weld metal during welding, minimizing oxidation.
Ferro-titanium Ferro-carbon-titanium	To deoxidize and denitrogenize during welding, minimizing formation of oxides of iron, manganese, etc., and nitride of iron in and adjacent to the weld, finally entering slag for protection.
Gum Arabic and other water-soluble gums	Binder and dispersing agent; also furnishes carbon oxides on burning (see CARBONACEOUS MATERIAL).
Ilmenite or titaniferous iron	To supply oxydic compound of titanium and contribute to the formation of a suitable slag (see TITANIUM DIOXIDE).
Iron ore	In conjunction with ilmenite to adjust the titanium content and also the manganese content.
Iron Oxide	In certain proportions with titanium dioxide, silica and silicates, said to contribute to arc stability.
Kaolin (see Clay)	
Magnesium Carbonate (As such or when present in silicates)	To provide carbon oxides to blanket weld and to form slag.
Magnesium Oxide	To adjust basicity and other properties of slag.
MAGNESIUM SILICATES	See Asbestine, Asbestos, etc.
Manganese carbonate Manganese dioxide Manganese ore (pyrolusite)	To provide a reducible compound of manganese usually along with elemental manganese alloy, or silicon alloy, etc., finally to transfer unoxidized manganese from the coating to the weld.
Manganese-titanium	Deoxidizer—denitrogenizer (see Ferro-titanium)
Mica (pyrophyllite)	See Aluminum-bearing silicates.
Molybdenum and compounds	Introduced usually as a molybdate for alloying (see Calcium Molybdate).
ORGANIC MATERIAL	See CARBONACEOUS MATERIAL.
Paper, paper pulp—fibrous	See CARBONACEOUS MATERIAL.
Potassium Feldspar	See Feldspar.
Potassium Silicate	Binder and source of potassium and silicate for the slag.
RUTILE and rutile-bearing minerals	To furnish a titanium dioxide.
SILICA Silica flour, amorphous silica, etc.	To form slag, regulate its consistency and melting point and contribute to protection of weld and quality of the arc; such functions may result from reaction of SiO_2 with Na_2O, CaO, MgO when these are present as such or from decomposition of silicates or carbonates; finely divided amorphous silica also provides bulk to obtain satisfactory thickness of coating.
SILICATES (See Asbestos, Clay, Magnesium Silicate, Talc, etc.)	
Silico-manganese	To provide for the transfer of silicon and manganese from the coating to the weld, during welding.
Silicon Esters	Binder.
Slag	Electric furnace or open hearth, dried and powdered as a diluent and mechanical thickener and quieter.
Sodium carbonate	To provide carbon oxide gases but primarily to react with titanium dioxide to form sodium titanate and with silica to form sodium silicate.
SODIUM SILICATE	Most widely used liquid binder for ingredients of coating—also contributes to formation of slag.
Sodium titanate	Former or added as such carries titanium dioxide for arc stabilization, and into slag.
Talc (See Asbestos, etc.)	
TITANIUM DIOXIDE (As such or from other compounds, titanium ores, etc.)	To stabilize and steady the arc and contribute continuity, uniformity and impermeability to the slag—thus protecting the weld metal from reaction with the contact atmosphere. To deoxidize and denitrogenize the weld metal and surrounding contact atmosphere should reduction occur. To reduce impressed voltage required and to speed up the welding process.
Tungsten	Alloying element.
Uranium	Alloying element.
Vanadium	Alloying element.
Water	To dissolve and dilute sodium silicate or other binders and to regulate consistency of coating mix during application.
Wood flour Wood pulp, etc.	See CARBONACEOUS MATERIAL.
Zirconia or Zirconia ore	In conjunction with oxydic compound of titanium imparts desirable properties to the slag.

The Application of Copper-Oxide Rectifiers for Resistance Welding*

By R. L. Briggs†

Introduction

THERE has been an increasing interest in and use of three-phase systems for resistance welding. This has been due largely to the limiting capacities of available single-phase systems for welding loads. The impulse loadings of poor power factor imposed by resistance welders on single-phase systems are a matter of serious concern to power suppliers. They are eager for any new methods which may improve present conditions. In many cases power companies could supply the desired welding power if the loading could be balanced on a three-phase system or if the power factor could be improved.

Two solutions to the power supply problem are available. One method involves the use of series capacitors to correct the power factor of welders on a single-phase system. The more important method is the application of the energy storage principle to resistance welding. Undoubtedly the amazing growth of resistance welding in the aircraft industry is due to the use of this type of equipment, since few manufacturers have sufficient single-phase power available to do equivalent welding with single-phase resistance welders. The chief disadvantage of the energy storage method lies in its restricted application due to the relatively uncontrolled rate of application of the stored energy when welding.

A third possible solution would be in the development of a three-phase system having a welding output which could be applied over any selected time interval. An examination of the possible methods of obtaining sufficient current in amperes for resistance-welding purposes indicated that dry-type rectification of a three-phase low-voltage high-current system would be practical. I propose to describe such a system and illustrate its operating character and application to a given job.

The Copper Oxide Rectifier

The basic circuit of the three-phase rectifier is shown on Fig. 1. $L_1L_2L_3$ is the three-phase a.-c. power supply. WR is the input contactor with contacts W. This contactor is controlled by a timing contact T and a safety contact S. The three-phase transformer is connected in delta-wye, and the low-voltage high-current secondary output is connected to the rectifiers R. The rectifiers are connected in the standard bridge circuit allowing full wave rectification. The manual switch M controls the three blower fans used to cool the rectifiers. Tube contactors or synchronous control of power input is practical.

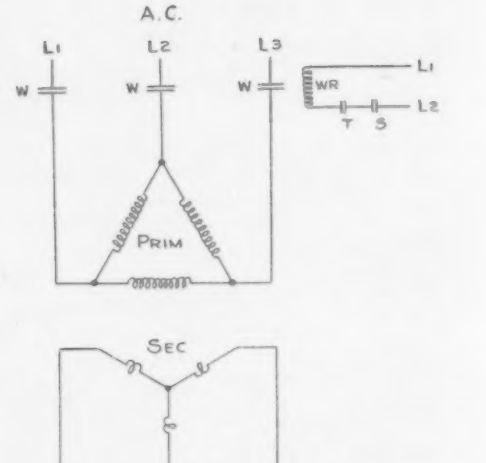


Fig. 1

The bridge-type circuit was chosen in preference to the center-tap half-wave three-phase rectifier circuit for several reasons. First, the construction of the power transformers was simplified. Second, the interconnecting busses were shortened. Third, when using the same power transformers and same rating of rectifiers the bridge circuit will deliver 2.35 times the power output of the center tap circuit. It should be noted in this respect, however, that when using the same rating of power transformer and the same rectifier plate area, the center tap circuit will give the larger values of welding current than the bridge circuit but at lower output voltages.

A copper oxide rectifier has certain limitations of use and application. First, we are told that the maximum a.-c. voltage which should be applied to double-stacked rectifiers is 25 v. with a working maximum of 20 v. We find that these limitations should be maintained but that at these upper ranges of a.-c. voltages great care must be taken to prevent the application of voltage to an unloaded rectifier. This means that further study must be made to adapt a unit of this type to flash weld-

* Presented at the 23rd Annual Meeting A.W.S., Cleveland, Ohio, Oct. 12 to 14, 1942.

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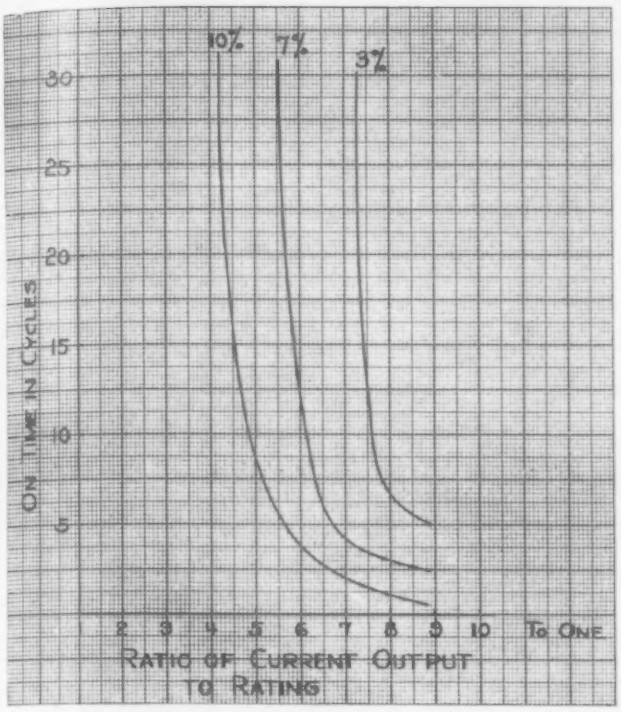

Fig. 2

ing. Second, we are told that the rectifier's useful life is largely determined by the operating temperature. A maximum-operating plate temperature of 45°C. will insure indefinite welding life, but the lower the operating temperature the better.

Provided we are careful to stay within the limitations described, the copper-oxide rectifier has unusual capacities. There is evidence to indicate that it can rectify a current up to as high as 25 times its continuous rating. It is also clear that as more and more rectifier plates are paralleled, thus increasing the rectifier continuous rating, we obtain a drop in the input power required to obtain a given magnitude of output d.-c. amperes. Putting this fact in another form, we can increase the efficiency of the rectifiers by decreasing the rectifier-plate current density.

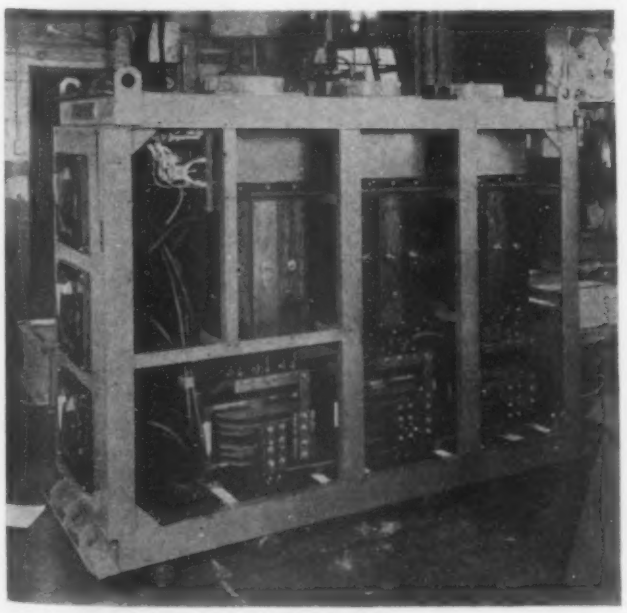

Fig. 3

Characteristics of the Full-Wave Rectifier

Certain relationships of currents and voltages in the full-wave copper-oxide rectifier are interesting. Neglecting losses, the total output power in watts equals the total input power in volt amperes, and the output in watts is 1.73 times the line loading in volt amperes on a single phase.

The d.-c. output voltage and current of the rectifier unit is 34.5% higher than the r.m.s. a.-c. voltage and current applied to the unit.

From these relationships we can expect that a well-designed unit should operate at power factors considerably higher than the conventional single-phase a.-c. resistance welders. We should also expect that when

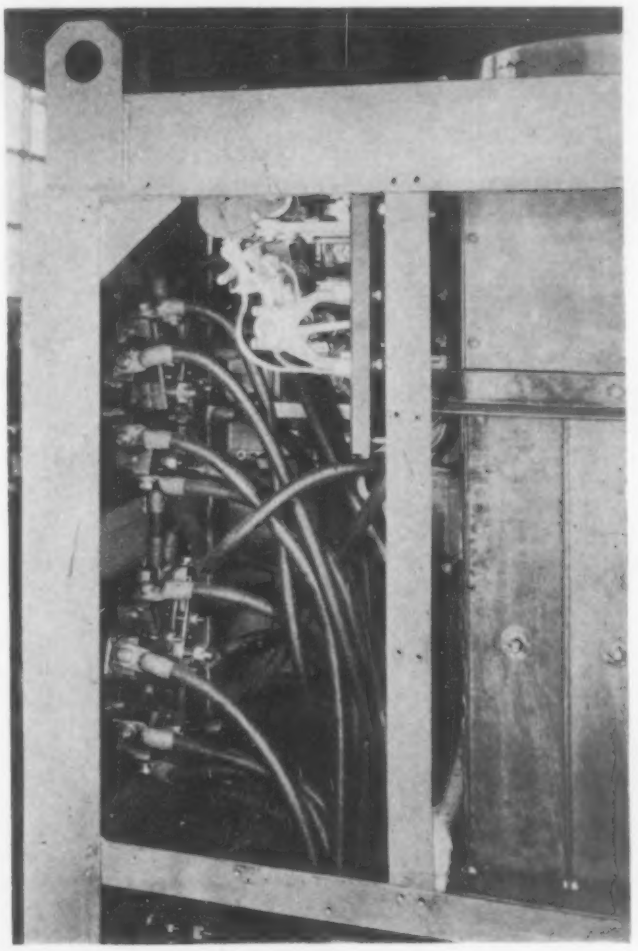

Fig. 4

delivering the same magnitude of welding amperes it would reduce the line loading per phase by a value approaching 42% as a theoretical maximum. These figures should certainly interest the power companies.

By a reduction in the operating duty cycle we may obtain rectification of currents many times larger than the continuous rating. Figure 2 shows a few of the more interesting capacity curves of a three-phase bridge-type copper-oxide rectifier. Each curve is a plot of ON time against the allowable current output ratio to the rated output. Each curve represents a condition of a fixed duty cycle or ratio of ON time of the current to the total time for any given period. All curves are based on an allowable maximum rectifier-plate operating temperature of 35°C.

A study of the capacity curves reveals many interesting features. You will note the apparent indication

that up to a certain increase in output the length of the ON time or period of current flow has little effect provided the duty cycle is held constant. Take, for example, a unit rated at 1000-amp. continuous duty. The curves indicate that the unit may be safely employed to handle 4200 amp. at 10% duty cycle regardless of the length of the ON time. Within practical welding-operating limits, this seems to be true. At the given duty cycle ON times of several seconds were used. Using increasingly longer ON times, however, necessitates lower values of current to prevent overheating, and the curve falls off to the unity ratio.

The use of low-duty cycles such as 3% results in a copper-oxide rectifier capacity which is in excess of seven times its continuous-rated capacity. For example, a 3000-amp. continuous-rating unit will deliver 22,500 amp. for 15-cycle welding at 3% duty cycle.

Experimental evidence indicates that with more efficient cooling these duty-cycle curves are displaced to the right, the slope of the abrupt rise is not so steep and the knee is higher. Based on reasonable deductions it is indicated that rectifier-plate redesign, based on new cooling methods, may result in units capable of operating at 10 to 15 times their continuous rating at duty cycles above 10%.

Factor of Design

In designing a unit for a given application certain procedure was found necessary. An example is the application of a unit to deliver power for gun welding at the end of two 150-ft. flexible cables each of one million-circular mil cross section. The nature of the job to be done was studied and 10,000 amp. was fixed as the magnitude of current for welding, with an operating duty cycle of 10%. From the capacity curves we see that a rectifier unit of 2500-amp. continuous rating would be suitable. A 3000-amp. unit was chosen. The voltage required to force the selected magnitude of current through the cables and welded work was calculated. This value of output voltage times the output current load gives the magnitude of output power. Three low-reactance single-phase transformers of suitable output voltage and capacity were selected. Here we should note that these units must be capable of maintaining the desired a.-c. voltage on the rectifiers under the load. Interconnecting busses having a cross section suitable for the loading were chosen, and the rectifier units were provided with air blowers having the air capacity recommended for use with the units.

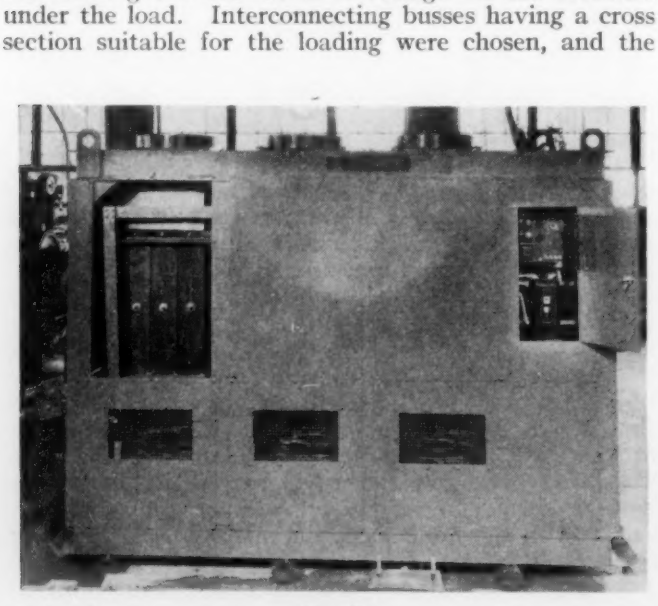

Fig. 5

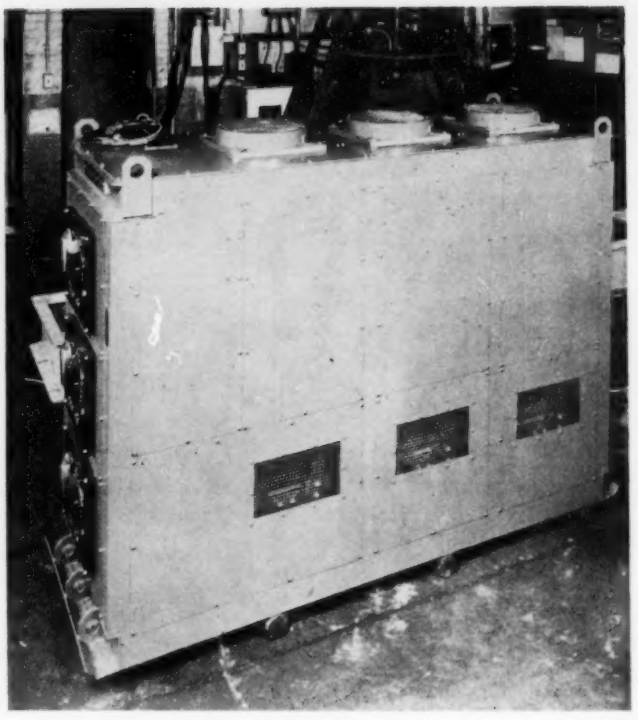

Fig. 6

Operating Characteristics of the 3000-Amp. Unit

The operating characteristics of the unit previously described indicate the possibilities which can be expected in future units with rectifier elements designed for welding service.

Figure 9 shows the effect of the length of one million circular-mil portable welding cables on the maximum output of the unit. The d.-c. voltage through the cables and rectifier is in all cases 34.0 v. Note that gun welding 150 ft. from the unit has 10,500 amp. available. At 75 ft. we have 11,800 amp.; at 50 ft., 13,500; at 25 ft., 17,700 amp.; and at 12½ ft. we have 23,000 amp. available for gun welding.

Figures for the kva. loading on the three-phase power lines for these different distances are interesting:

At 150 ft. we drew 324 kva.
At 75 ft. we drew 362 kva.
At 50 ft. we drew 415 kva.
At 25 ft. we drew 545 kva.
At 12½ ft. we drew 700 kva.

These loading figures become even more striking if compared with single-phase loadings of conventional gun welders delivering the equivalent current out the same distance over the identical portable welding leads:

Distance to Gun	3-Phase, Kva.	Single-Phase, Kva.
150	324	1000 est.
75	362	875 est.
50	415	650
25	545	650
12½	700	750

For a given type of loading on the unit the output current in amperes varies nearly linearly with the a.-c. voltage applied to the rectifier units.

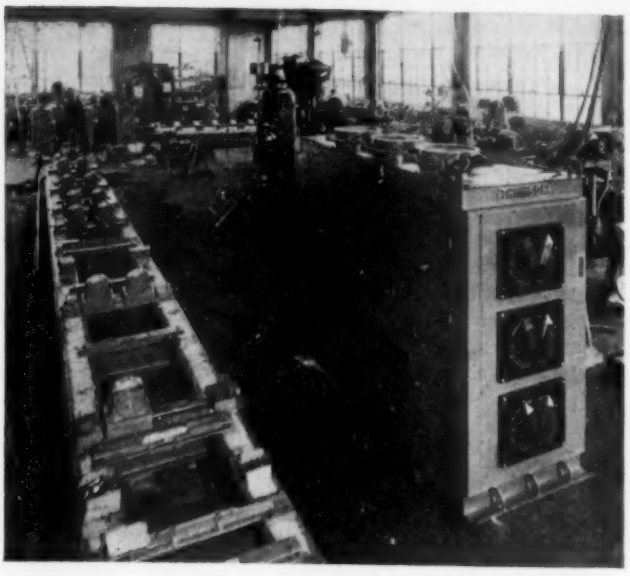

Fig. 7

Since direct current is used for welding current, it follows that the inductance of the portable welding leads has no effect upon the magnitude of the welding current. Only the resistance of the circuit limits the magnitude of current which can be obtained. The inductive effect however, delays the growth of the current to its maximum value. In the case of welding with two 150-ft. cables loosely laid together along the floor, it was found that approximately $^1/_{30}$th of a second was required for the current to build up to its maximum. No description has been given of what materials can be welded on the unit and in what sizes. It must be clear to all who are familiar with the art that a d.-c. ampere will heat as much as an a.-c. ampere. Hence, all mention of welding has been eliminated from this paper. The emphasis has been placed where it belongs—on ampere output.

Economic Considerations

For purposes of obtaining some means of cost comparison the following approximate figures are given for the cost of this type equipment designed for welding services. By using these figures in conjunction with the capacity and loading curves it is possible to arrive at an estimate which will serve as a comparison for costs of similar single-phase welding equipment. It should be noted that the costs are oversimplified to facilitate the making of comparisons.

1. For 30,000-amp. short throat welders, $2^1/_2$ times standard welder costs.
2. For 30,000-amp. deep throat welders, 2 times standard welder costs.
3. For 10,000-amp. gun welders 10-ft. leads, 2 times standard welder costs.
4. For 10,000-amp. gun welders 20-ft. leads, $1^1/_2$ times standard welder costs.
5. For 10,000-amp. gun welders 30-ft. leads, same.
6. For 30,000-amp. seam welders, medium throat, 5 times standard welder costs.
7. For aluminum welding in aircraft, $3^1/_2$–3 times standard welder costs.

Conclusion

On the basis of costs alone, it would appear that the copper-oxide rectifier would be serviceable and economically justifiable only in the cases where welding was to be done at distances of 15 ft. or more from the welding-power unit.

We must not overlook, however, the fact that the present rectifying elements were not designed for resistance-welding service and that they are capable of easy alteration allowing lower internal losses. We should remember the inherent advantages which will follow the development of more efficiently cooled rectifier plates.

There is substantial evidence that when the coming development of rectifier elements designed for this high-current moderate-duty cycle service has been completed, we may expect the d.-c. units to compare favorably in size and price with standard single-phase welding equipment. In any case, this system of welding offers a practical solution to the problem of balancing welding loads on a three-phase system and improving the power factor.

Figure 3 shows the construction of the 3000-amp. unit. The three-phase bridge type of rectifier has three "bridge" rectifying units, each of which is fed from the outer legs of the three wye-connected single-phase transformer secondaries. Note the vertical type of simplified construction with each rectifying unit mounted directly over and close to a transformer. Note that each unit is individually cooled by an air blast so restricted by ducts that it passes through the rectifier.

The primaries of the transformers are tapped to give the desired range of output d.-c. voltage and the primary current is controlled by a three-pole magnetic contactor.

Figure 4 shows a close-up of this contactor and the backs of two of the voltage regulators. These regulators provided means of obtaining sixteen adjustments of output d.-c. voltage.

Figure 5 shows the timing control and control power switch provided for the unit. The timer is calibrated in

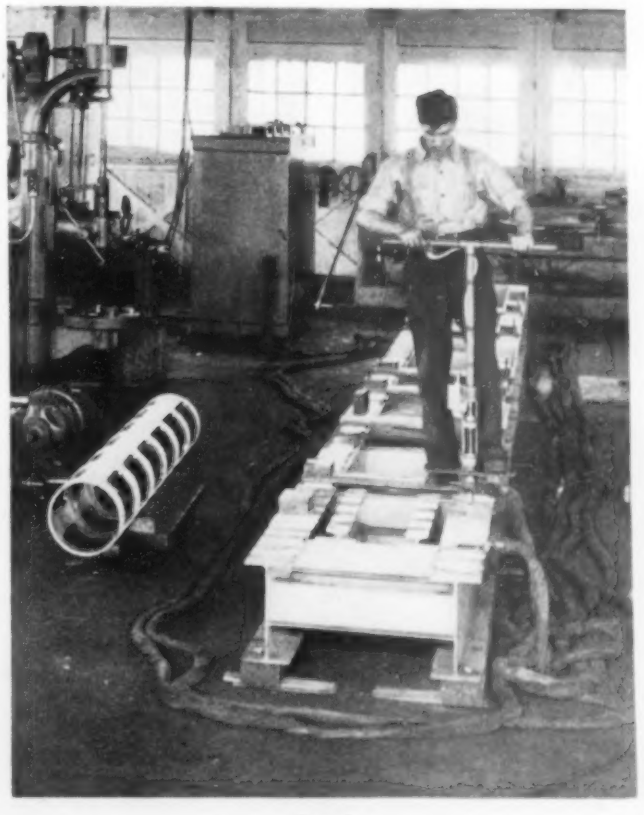

Fig. 8

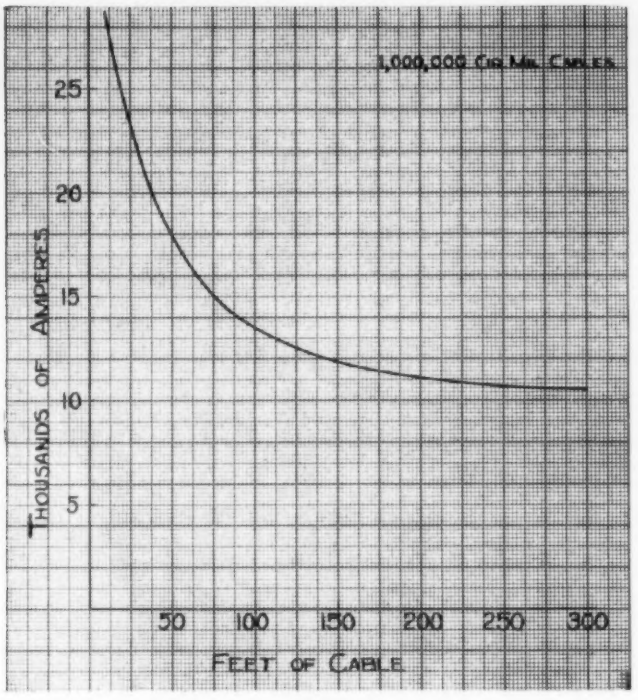

Fig. 9

one-cycle steps from 1 to 300 and is of the straight time non-synchronous type.

Figure 6 gives us a view of the Ventura blower outlets and the three-phase line power-supply inlet.

The unit is approximately 6 ft. high by 11 ft. long by $2^1/_2$ ft. wide.

Figure 7 shows to a limited extent the two 150-ft. flexible leads used in testing the operation of the unit over such distances. As will be noted, the leads were laid out along the side of a long steel base member and under such circumstances the unit was able to deliver the expected magnitude of welding current to the gun. It also shows an end view and the voltage regulators or tap changing switches supplied with the unit. All switches should be set on the same setting of the d.-c. output is to be uniformly shared by each of the rectifier bridges. An improvement in the design would have been to control the three tap switches from one position. Still further improvement would have been possible with Ignitron tube contactors supplied with heat control to regulate the input.

Figure 8 gives perhaps a better picture of the arrangement and more emphasis to the distance which could be established between the welding gun and the unit.

Efficiently Rigid Arc-Welded Connections*

By R. P. V. Marquardsen†

ALTHOUGH the process of arc welding, as applied in structural engineering, has progressed rapidly in recent years, it seems to the writer that the one great opportunity for profiting from this process has been overlooked entirely, viz., the development of efficiently rigid connections for use between the several members of a structure.

By an "efficiently rigid connection" the writer means a connection having a shear value and resisting moment equal to, or greater than, the shear value and resisting moment of the supported beam or girder.

The chief advantages derived from the development and use of efficiently rigid connections may be summarized as follows:

1. A reduction in the quantity of steel required for girders and beams, of not less than 25%.
2. An increase in the allowable span length (as limited by deflection requirements) of not less than 35%, for any given beam supporting a given total load.
3. A more nearly rational basis for designing columns, due to the fact that the moments can be determined more accurately.

In order to develop mathematically an efficiently rigid connection, an analysis of the strength of the various types of welds in general use is a prerequisite.

Such an analysis need not necessarily be absolutely correct mathematically, so long as the results obtained are known to be on the side of safety and are fairly accurate. As a matter of fact, the writer is of the opinion that the simpler an analysis is, the greater in all probability will be the number of engineers who will take the time to acquaint themselves with it.

In order to simplify the analysis that follows, welds will be divided into four general classes:

1. Tension Welds, which will include all welds that are subject to direct tensile stresses only.
2. Compression Welds, which will include all welds that are subject to direct compressive stresses only.
3. Bending Welds, which will include all welds that are subject to bending stresses.
4. Shear Welds, which will include all welds that are subject to shearing stresses principally.

Each of these classes will be subdivided further into several types, depending on the shape of the cross section of the weld, as, for instance, rectangular welds, triangular welds, sector welds, V-welds, Double V-welds, U-welds, Double U-welds, etc.

The following nomenclature will be used:

* Third Prize Award paper in the Buildings and Similar Structures Division E1 of the 1940–42 Industrial Progress Award Program sponsored by The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio. The award papers showed a possible saving of $1,825,000,000, including 7,000,000 tons of steel and 153,000,000 man-hours of labor available by application of arc welding.

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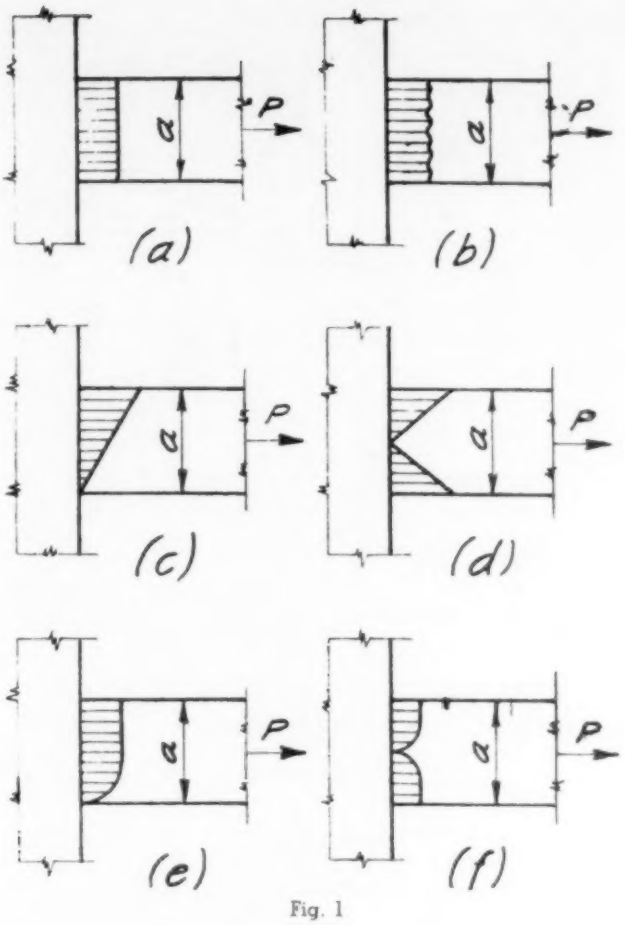

Fig. 1

f_T = Allowable unit tensile stress in the weld material, in pounds per square inch.
f_C = Allowable unit compressive stress in the weld material, in pounds per square inch.
f_B = Allowable unit bending stress in the weld material, in pounds per square inch.
f_S = Allowable unit shearing stress in the weld material, in pounds per square inch.
a = Width of weld, in inches, subject to direct tension or compression, in tension and compression welds.
b = Depth of "cantilever" in bending welds, in inches.
c = Length of "cantilever" in bending welds, in inches.
d = Dimension, in inches, of either side of the weld, in triangular shear welds.
e = Radius of the weld, in inches, in sector shear welds.
l = Length of the weld under consideration, in inches.
S_T = Total working strength of tension weld, in pounds.
S_C = Total working strength of compression weld, in pounds.
S_B = Total working strength of bending weld, in pounds.
S_S = Total working strength of shear weld, in pounds.

Tension Welds

In Fig. 1 are shown several types of tension welds. Evidently the strength of these welds are the same, inasmuch as the shape of the cross section of any tension weld (i.e., whether rectangular, single or double V or U) obviously is immaterial as far as strength is concerned.

The working strength of tension welds therefore may be expressed by the following formula:

$$S_T = alf_T \qquad (1)$$

Compression Welds

Compression welds are similar to tension welds, the only difference being that the welds are in compression instead of in tension. The working strength of a compression weld therefore is given by the following formula:

$$S_C = alf_C \qquad (2)$$

Bending Welds

In Fig. 2 is shown a bending weld. In analyzing the strength of this weld it is assumed that a *tensile* force P is applied as indicated and that bar A is so held that only tensile stresses will occur at right angles to section C-C of the weld. Evidently a similar analysis may be employed if a *compressive* force is applied in the same manner.

The weld may be considered to be a cantilever, rigidly attached to bar A and supporting a varyingly distributed load whose intensities are proportional to the ordinates of the elastic curve of the cantilever, with the pointed end of the cantilever as the origin, the maximum load intensity being equal to f_T. A parabola with its origin at the point of support very nearly fulfills this condition (see also Fig. 3).

Considering a unit length of weld, the total load on the cantilever is $^2/_3cf_T$, and f_T being the allowable unit tensile stress, the total strength of the weld (per unit of length), as far as section C-C is concerned, is $^2/_3cf_T$. For all practical purposes only direct tension occurs at this section.

The total shear along the line of support of the cantilever (section B-B) is equal to the total load $^2/_3cf_T$. The section of the cantilever is rectangular at the support, and the maximum unit shear at the section, being one and one-half times the average, is therefore $^2/_3cf_T$ divided by $^2/_3b = (c/b)f_T$. This means that, in order for the weld

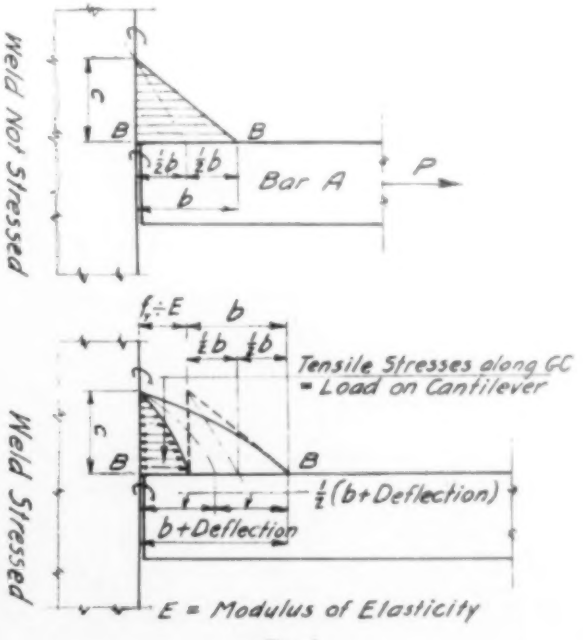

Fig. 2

to be as strong in shear at section B-B as it is in tension at section C-C, the value of c/b must be equal to f_S/f_T. If c is equal to b and if f_S/f_T is equal to only 11,300/13,000, the total strength of the weld (per unit of length), as far as shear along section B-B is concerned, is $0.580cf_T$.

The maximum bending moment at the support is $^2/_3cf_T$ times $^3/_8c = {}^1/_4c^2f_T$. The section modulus of the section being $^1/_6b^2$, the maximum fiber stress is therefore $^1/_4c^2f_T$ divided by $^1/_6b^2 = {}^3/_2(c^2/b^2)f_T$. If b is equal to c, the maximum fiber stress is $^3/_2f_T$, and the strength of the weld would be only $^2/_3cf_T$ divided by $^3/_2 = {}^4/_9cf_T$, but if b is made $\sqrt{3/2}$ greater than $c(= 1.22c)$, the strength of the weld, as far as bending stresses are concerned, will be as strong as the weld is along section C-C, assuming that f_B is equal to f_T. Obviously b should be made equal to $1.22c$ for economic reasons.

The working strength of bending welds therefore may be found by applying the following formulas:

When b is equal to c:

$$S_B = {}^4/_9clf_T \qquad (3)$$

When b is equal to $1.22c$:

$$S_B = {}^2/_3clf_T \qquad (4)$$

Shear Welds

In Fig. 4 are shown two bars, A and B, welded together on two sides with shear welds. View (a) is a plan, (b) an elevation, and (c) and (d) alternate cross sections of the bars and shear welds. The cross section at (c) shows triangular shear welds and the cross section at (d) shows sector shear welds. The two bars A and B, for the sake of simplicity in analyzing the strength of the welds, are assumed to have equal cross-sectional areas.

The ordinates of the curves shown at (e) indicate the distances that the cross sections of the bars (along the length of the weld) move from their original positions under the varying tensile stresses in the bars. The ordinates of the curve *above* line a-b represent the movements *toward the right* of the cross sections of bar A, and the ordinates of the curve *below* line a-b represent the movements *toward the left* of the cross sections of bar B. Either curve may be considered to be a parabola (which assumption is on the side of safety), the origin of the bar A curve being at a and the origin of the bar B curve being at b.

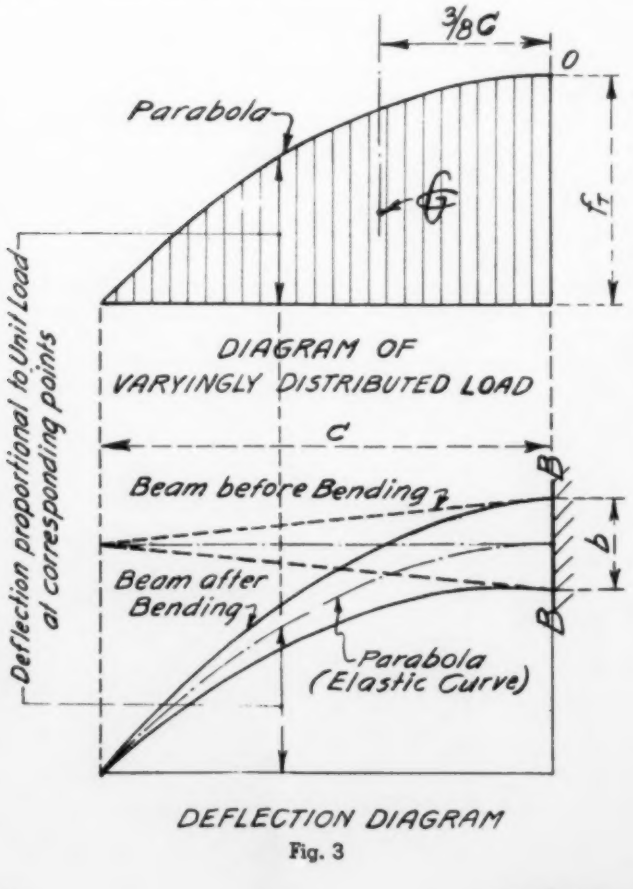

Fig. 3

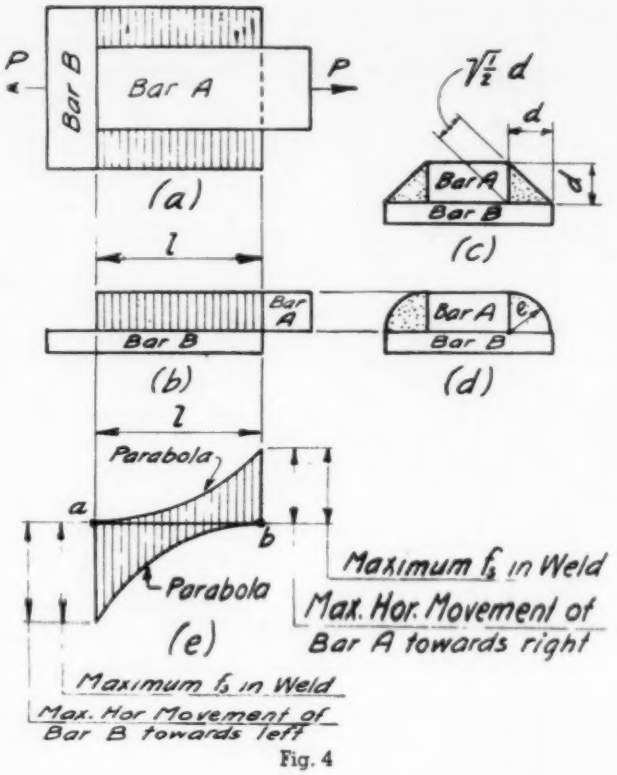

Fig. 4

Inasmuch as all corresponding cross sections of the two bars move in opposite directions, the sum of any two corresponding ordinates represents the total movement (away from each other) of the two cross sections under consideration; and inasmuch as the unit shearing stress in the weld at any point is proportional to the total movement of corresponding cross sections at that point, it follows that the sum of the ordinates also represents the unit shearing stress in the weld.

The total area of the ordinates diagram is $^2/_3lf_S$, which, multiplied by the minimum depth of the weld gives the total strength of the weld per side.

For welds of triangular cross section, as shown at (c), the minimum depth of the weld is $\sqrt{1/2}d$, and the total working strength of the weld per side is therefore $\sqrt{1/2}d$ times $^2/_3lf_S$, or

$$S_S = 0.472dlf_S \qquad (5)$$

For welds whose cross-sectional area is the fourth part of a circle, as shown at (d), the depth of the weld is equal to e, and the total working strength of the weld per side may therefore be found by applying the following formula:

$$S_S = {}^2/_3elf_S \qquad (6)$$

In other words the total working strength of a triangular shear weld is only about 70% of the total working strength of a sector shear weld, assuming that d is equal to e.

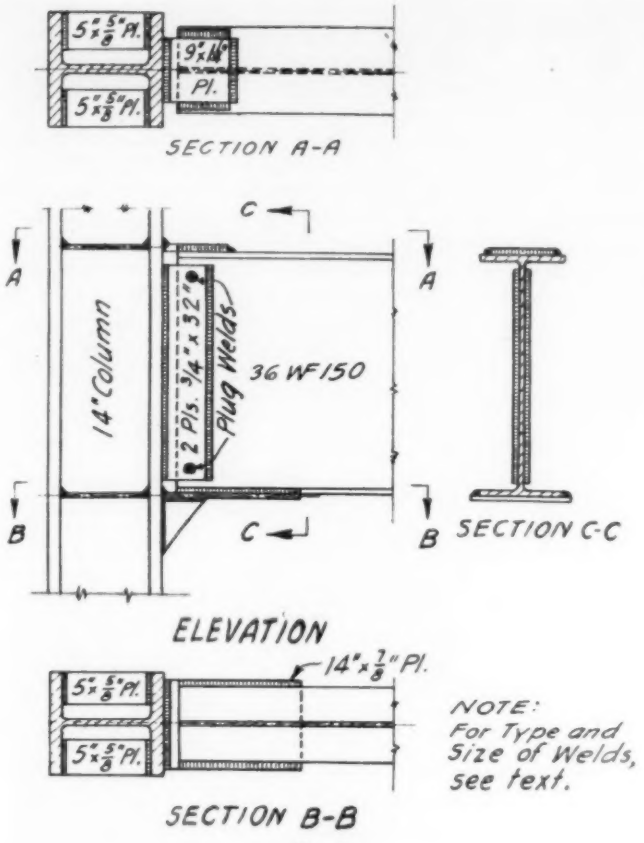

Fig. 5

Efficiently Rigid Connections

Formulas for ascertaining the working strength of tension, compression, bending and shear welds having been derived, the design of a typical efficiently rigid connection can now be developed.

As an example, an efficiently rigid connection will be developed between a 36-in. wide-flange structural-steel beam and the flange of a 14-in. column. The result of this study is shown in Fig. 5 and references to this figure will be made throughout the design of the connection.

For convenient reference, the properties of the 36-in. beam are listed below:

Total depth of beam = $35^{7}/_{8}$ in.
Width of flange = 12 in.
Thickness of flange = $^{15}/_{16}$ in.
Area of flange = 11.25 in.^{2}
Depth of web = 34 in.
Thickness of web = $^{5}/_{8}$ in.
Area of web = 21.25 in.^{2}
Section modulus of beam = 502.9 in.^{3}

The following numerical values for allowable unit stresses in the weld material will be used:

f_T = 13,000 psi.
f_C = 15,000 psi.
f_B = 13,000 psi.
f_S = 11,300 psi.

The allowable unit stress in the beam and the connection plates will be taken equal to 20,000 psi. for tension, compression and bending and equal to 15,000 psi. for shear.

The design of an efficiently rigid connection may conveniently be made in three separate operations, viz., designing (1) the top-flange connection; (2) the bottom-flange connection; (3) the web connection; and each of these three designs may be subdivided further into designs for (*a*) welds between connection plates and girder, and (*b*) welds between connection plates and column.

This procedure will be followed in the design of the typical connection under consideration.

Top-Flange Connection

The cross-sectional area of the top flange is 11.25 in.^{2} and its total working strength is therefore 225,000 lb.

A 9-in. wide by $1^{1}/_{4}$-in. thick connection plate has the same cross-sectional area and is therefore adequate.

To allow for necessary adjustments during erection, only field welds should be used, and overhead welds should therefore be avoided.

The welds between the connection plate and the beam may consist of:

One bending weld ($1^{1}/_{4}$ x $1^{5}/_{8}$ x 9 in.):
By formula (4) = $^{2}/_{3} \times 1^{1}/_{4} \times 9 \times 13{,}000$ = 97,500 lb.
Two sector shear welds (each $1^{1}/_{4}$ x 7 in.):
By formula (6) = $2 \times {}^{2}/_{3} \times 1^{1}/_{4} \times 7 \times 11{,}300$ = 131,800 lb.
Total 229,300 lb.

Or, if it is desired to use right-angle equilateral triangular welds, the following combination may be used:

One bending weld ($1^{1}/_{4}$ x $1^{1}/_{4}$ x 9 in.):
By formula (3) = $^{4}/_{9} \times 1^{1}/_{4} \times 9 \times 13{,}000$ = 65,000 lb.
Two triangular shear welds (each $1^{1}/_{4}$ x $1^{1}/_{4}$ x 12 in.):
By formula (5) = $2 \times 0.472 \times 1^{1}/_{4} \times 12 \times 11{,}300$ = 160,000 lb.
Total 225,000 lb.

Other combinations, of course, could be used.

The welds between the connection plate and the column may consist of:

One tension weld ($1^{1}/_{4}$ x 9 in.):
By formula (1) = $1^{1}/_{4} \times 9 \times 13{,}000$ = 146,000 lb.
One bending weld ($1^{1}/_{16}$ x $1^{5}/_{16}$ x 9 in.):
By formula (4) = $^{2}/_{3} \times 1^{1}/_{16} \times 9 \times 13{,}000$ = 83,000 lb.
Total 229,000 lb.

The total potential stress in the top flange of the beam is now transferred to the adjacent flange of the 14-in. column.

To transfer one-half of the stress to the other flange of the column to obtain equal distribution, two plates (one on each side of the column web) may be shop welded to the flanges.

The cross-sectional area of these plates need only be one-half of the area of the connection plate. Their center lines should coincide with the center line of the connection plate, as indicated in Fig. 5. If each plate is 5 x $^{5}/_{8}$ in., the welds to each column flange per plate may consist of:

One tension weld ($^{5}/_{8}$ x 5 in.):
By formula (1) = $^{5}/_{8} \times 5 \times 13{,}000$ = 40,600 lb.
One bending weld ($^{5}/_{8}$ x 5 in.):
By formula (3) = $^{4}/_{9} \times {}^{5}/_{8} \times 5 \times 13{,}000$ = 18,100 lb.
Total 58,700 lb.

The welds, of course, can be made in the shop.

Bottom-Flange Connection

The connection plate for the bottom flange should be shop welded to the column and be provided with a ver-

tical stiffener (as indicated in Fig. 5) so that it may be used as a seat for the beam during erection. Also, it must be wider than the beam flange in order to furnish a base for field welding to the beam.

A 14-x $^7/_8$-in. plate will fullfill this requirement and will be adequate as far as cross-sectional area is concerned.

The welds between the connection plate and the beam may consist of:

Two sector shear welds (each $^7/_8$ x 17 in.).
By formula (6) = $2 \times {}^2/_3 \times {}^7/_8 \times 17 \times 11{,}300$ = 225,000 lb.

The welds between the connection plate and the column may consist of:

One tension* weld ($^7/_8$ x 14 in.):
By formula (1) = $^7/_8 \times 1 \times 14 \times 13{,}000$* = 159,000 lb.
Two bending welds (each $^5/_{16}$ x $^3/_8$ x 14 in.):
By formula (4) = $2 \times {}^2/_3 \times {}^5/_{16} \times 14 \times 13{,}000$ = 76,000 lb.
Total 235,000 lb.

The welds of the stiffener plate need only be nominal: A $^3/_8$-in. continuous weld on each side will suffice (see Fig. 5).

The same sized transfer plates and welds used at the elevation of the top flange of the beam, to transfer one-half of the stress from one column flange to the other, may be used at the elevation of the bottom flange of the beam.

Web Connection

The cross-sectional area of the web is 21.25 in.^{2} and its total allowable working strength is therefore 425,000 lb.

Two 32- x $^3/_8$-in. connection plates could be used as far as area is concerned, but difficulty would be encountered in getting sufficiently strong welds. Two 32- x $^3/_4$-in. connection plates will fit the conditions better.

The welds between each of these connection plates and the beam may consist of:

One bending weld ($^3/_4$ x $^{15}/_{16}$ x 32 in.):
By formula (4) = $^2/_3 \times {}^3/_4 \times 32 \times 13{,}000$ = 208,000 lb.

which multiplied by 2 gives the total working strength of the two plates, or 416,000 lb. This is 9000 lb. less than the working strength of the web, but this defficiency, if so desired, may be made up by the use of a few plug welds as indicated in Fig. 5.

The welds between each connection plate and the column may consist of:

One tension weld ($^3/_4$ x 32 in.):
By formula (1) = $^3/_4 \times 32 \times 13{,}000$ = 312,000 lb.

which multiplied by 2 is equal to 624,000 lb. for the two plates.

Neither the total working strength of the web nor that of the weld material is, of course, ever fully developed in bending, since the unit stress varies from zero at the center of the web to a maximum at the top and bottom, but it would seem logical to make the weld at least as strong as the web itself in order to obtain the same stiffness throughout.

General Check

The designs of the top-flange, bottom-flange and web connections constitute the entire design of the efficiently rigid connection, but a general check on the connection as a whole may be made as follows:

The section modulus of the beam is 502.9 in.^{3} and the total resisting moment is therefore 10,058,000 in.-lb.

The total resisting moment of the top-flange, bottom-flange and web connections may be computed roughly in the following manner:

The distance between the centers of the top and bottom connection plates is $36^{15}/_{16}$ in. and the allowable working strength of either connection is at least 225,000 lb.; hence, the resisting moment of these two connections is $225{,}000 \times 36^{15}/_{16} = 8{,}310{,}000$ in.-lb.

The minimum weld strength of the web connection is 416,000 lb. The depth of the plates is 32 in., and the distance between the centers of the top and bottom connection plates is, as stated above, $36^{15}/_{16}$ in. The total resisting moment of the web connection (by the section-modulus method) is therefore

$$\frac{416{,}000 \times 32}{6} \times \frac{32}{36^{15}/_{16}} = 1{,}920{,}000 \text{ in.-lb.}$$

which, added to the resisting moment of the top and bottom flange connections, makes a total of 10,230,000 in.-lb. for the efficiently rigid connection and is slightly greater than the resisting moment of the beam.

The allowable total shear on the unstiffened web of the 36-in. beam under consideration is 268,800 lb.

The minimum shear value of the connection welds is the shear strength of the welds between the connection plates and the beam, which by formula (5) is equal to

$$2 \times 0.472 \times {}^3/_4 \times 32 \times 11{,}300 = 256{,}000 \text{ lb.}$$

This is slightly less than the allowable shear on the web, but it should be good enough for all practical purposes inasmuch as shear seldom governs the size of the beam. If so desired, a few plug welds could be added to compensate for the deficiency, or the welds could be changed to sector welds.

Concluding Remarks

The writer does not claim that the foregoing analysis of the strength of the various types of welds is absolutely correct mathematically, nor that the preceding development of efficiently rigid connections is the only correct solution. His chief purpose has been to call attention to a great opportunity for advancing the arc-welding industry that seemingly has been overlooked, and incidentally to point out the steps that *could* be taken to remedy the situation.

The present practice among structural engineers (and, by the way, the only one sanctioned by many city codes) is to design the various beams and girder in a building as simple beams.

Nor is this practice very much out of line where so-called standard *riveted* connections are used, as a thorough analysis of such connections will show quite readily. As a matter of fact, *the angles of all standard riveted connections are stressed beyond the elastic limit* and to such an extent that the resisting-moment value of the connections as a whole is very small—practically nil.

But handbooks for *riveted* connections are at hand and it is so easy to follow the line of least resistance; hence, *riveted* connections and *simple-beam* designs!

And, now, what steps *could* be taken to remedy the situation?

The writer suggests that The James F. Lincoln Arc Welding Foundation prepare (or arrange to have prepared) for general distribution among structural engineers, designers and draftsmen, and at a nominal price, a *real* "Handbook on Welding for Structural Engineers," similar in character to the handbooks issued by the steel companies or by the American Institute of Steel Construction.

* Assuming that there might be a reversal of stress due to wind forces, it would seem advisable to use allowable tensile stresses rather than allowable compressive stresses.

Such a handbook should contain, in addition to the usual tables and general data of interest to structural engineers that are found in the other handbooks referred to above, a thorough analysis of the strength of the various types of welds and (instead of tables for standard *riveted* connections and other *rivet* information) tables for standard efficiently rigid arc-welded connections, properly arranged for ready reference. It should also contain a treatise showing how such standard arc-welded connections should be designed. In short, the handbook should be a reference book and a text-book combined, free from all advertising matter.

Any opposition by city codes to a rigid-frame design surely can be overcome if adequate proof is presented that really rigid connections can be constructed.

Proportionate Cost Saving

The proportionate cost saving per complete unit (i.e., by using an efficiently rigid arc-welded connection instead of a riveted connection) is not found in the actual costs of the two types of connections (which probably do not differ a great deal), but in the quantity of steel saved in the beam or girder occasioning the connection.

For instance, if the size of a given beam with a riveted connection is found by using a bending moment equal to $wl^2/8$, the size of the same beam with an efficiently rigid arc-welded connection would only be required to take care of a bending moment equal to $wl^2/12$ or less, or in other words there would be a proportionate saving of at least 25%.

Estimated Total Annual Gross Savings

The total annual gross savings accruing from a general adoption in the United States of efficiently rigid arc-welded connections for use in structural-steel buildings may be estimated as follows:

Assume that the annual U. S. production of structural shapes and plates is 2,500,000 tons for a normal prewar year, and that about 50% of this tonnage is used in buildings. Assume further that about 65% of the building steel represents girders and beams, the remaining 35% being columns.

The total steel used for girders and beams would therefore be $2{,}500{,}000 \times 0.50 \times 0.65 = 810{,}000$ tons. The total saving of this tonnage is not less than 25% or about 200,000 tons, which at an erected price of $100 per ton gives a total annual gross saving of $20,000,000.00.

Increased Service Life, Efficiency and Social Advantages

There would probably be no increase in service life accruing from the adoption of efficiently rigid arc-welded connections, but neither would there be any decrease.

Any efficiency accruing would be in the saving of time and labor in connection with the preparation of the detailed plans for the building. Such saving of time and labor, as any structural engineer can readily perceive, would not be inconsiderable, provided a *real* "Handbook on Welding for Structural Engineers," such as is described above, is at hand.

Among the social advantages accruing from the use of efficiently rigid arc-welded connections may be mentioned (*a*) the elimination of a lot of noise during erection, (*b*) lower total cost of the building and (*c*) a more rigid structure with less vibration and less swaying during severe wind storms.

Data on Costs and Cost Comparisons

As previously stated, the proportionate cost saving in using efficiently rigid arc-welded connections instead of the usual riveted connections is found in the quantity of steel saved in the girder or beam occasioning the connections. The cost of the connections themselves evidently is very small as compared with the cost of the girder or beam, and hence there would be no object in making elaborate comparisons between the cost of a riveted connection and the cost of an efficiently rigid arc-welded connection, especially since the actual costs of the two types of connections probably would be about the same at any rate.

Final Comment

The foregoing discussion should show conclusively that the general adoption of efficiently rigid arc-welded connections in the design and construction of structural-steel frames for buildings would constitute real progress in the process of arc welding, but the writer is of the opinion that until the necessary information is handed to the structural engineer on a silver platter (in the shape of a *real* "Handbook on Welding for Structural Engineers") progress along these lines will be slow.

1942 Electric Arc-Welding Developments

(*Continued from page 245*)

also by the widespread use of motion pictures to shorten the time required for training.

The past year witnessed a broad expansion of the use of previously developed equipment and processes. This was in line with the well-recognized necessity for standardization and avoidance of special requirements in achieving maximum productive efficiency. The application of atomic-hydrogen arc welding was largely extended in the aircraft field where such parts as propellers, landing gear parts, superchargers and oxygen cylinders were produced in large volume with the aid of atomic-hydrogen arc welding. A new multiple-arc automatic atomic-hydrogen arc-welding head went into production in 1942 for the high-speed welding of heavy-walled tubing.

Another notable development in the application field was the large increase in the use of a.-c. arc-welding equipment, and particularly its adoption in the shipbuilding field. Its use out of doors on subassembly work as well as in ship repair docks gives another strong indication of its almost certain widespread adoption in this field in the future.

There was a significant increase in the use of control equipment on single-operator welders for facilitating the filling of craters as well as for providing increased welding heat at the start of a weld, particularly on thin materials.

The resumption of development work for arc welding in atmospheres of inert gases, such as helium and argon, is particularly noteworthy. The process was commercially applied to the welding of magnesium, aluminum and the stainless steels.

In the electrode field, a long period of intensive development work culminated in the production of a Class E-6011 electrode for a.-c. welding in all positions, particularly the vertical and overhead positions. In conjunction with Class E-6020 electrodes, this electrode provides complete flexibility for the use of a.-c. welding on mild steel, and is therefore a very important contribution to productive efficiency.

Accessories were developed to keep pace with the needs of the industry, the most noteworthy addition being a line of protective clothing for women welders.

THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

NOMINEES FOR DISTRICT VICE-PRESIDENTS

New York-New England: F. C. Fyke, Materials Engineer, Standard Oil Development Co., General Engineering Dept., Elizabeth, N. J.

Middle Eastern: C. H. Jennings, Research Engineer, Westinghouse Electric & Mfg. Co., Research Labs, East Pittsburgh, Pa.

Middle Western: G. N. Sieger, Pres. & Gen'l. Mgr., S.M.S. Corp., 1165 Harper Ave., Detroit, Mich.

Southern: E. C. Chapman, Metallurgical Engineer, Combustion Engineering Co., Inc., Chattanooga, Tenn.

Pacific Coast: J. C. Gowing, representing Hobart Bros., Arc Welders and Eutectic Welding Alloys, Inc., 1007 Santa Fe Ave., Los Angeles, Calif.

Article V, Section 6, By-Laws: ". . . The nominations made by the Districts shall be published in the April issue of THE WELDING JOURNAL of the AMERICAN WELDING SOCIETY.

"Independent nominations may be made by a petition of twenty-five (25) or more members sent to the National Secretary not later than May 15th; such petitions for the nomination of District Vice-Presidents shall be signed only by members within the district concerned.

"Only District members shall be eligible to vote for District Vice-Presidents."

ANNUAL MEETING

The Annual Meeting of the AMERICAN WELDING SOCIETY is shaping up to be an outstanding event in connection with the furthering of the war effort. The program is developing into some eighteen sessions covering every phase of welding of direct interest to war production work, including Railroad Welding, Tubing, Cutting, Ships, Aircraft, Inspection, Qualification and Training, Resistance Welding, Weldability, Research, Non-ferrous Welding and Brazing, Piping, Flame Hardening and Softening, Production, Repair and Maintenance, and Metallurgy.

The Hotel Morrison, Chicago, has been selected as the headquarters for the Society. Following the pattern of last year, the technical portion of the program will be confined to a three and a half days' session with two and three simultaneous sessions occurring practically all the time. All the frills of ladies' entertainment, president's reception and annual dinner and banquet have been dispensed with.

BACK NUMBERS OF THE JOURNAL

The AMERICAN WELDING SOCIETY is short of a number of back copies of THE WELDING JOURNAL. These are in demand by workers in defense industries and by libraries.

A list of the issues which the SOCIETY would like to obtain is given below. Any member who has no need for his back copies will be conferring a favor on the SOCIETY if he sends them in. If some reimbursement is desired, the Society is willing to pay 25¢ per copy sent in.

November 1934
January, February, March and September 1935
January, August, September and October 1936
March, April, May, June, July, August and December 1937
January, February, March, May and November 1938
January 1939
January, February, May, August, and December 1940
January and February 1941
October and November 1942

ORPHAN ELECTRODE STUBS ADOPTED BY NEW YORK BOARD OF EDUCATION

A quantity of electrode stubs accumulated by a manufacturer recently came into the willing possession of the New York Board of Education under rather unusual circumstances. The stubs were originally destined to be melted, but they are now in New York City's manual training schools doing their part in the training of welding operators.

The incident happened at a meeting in New York sponsored by several engineering societies, and held at the request of the WPB to discuss various manufacturing problems. Mr. E. Vom Steeg, Jr., General Electric welding specialist, had just concluded a talk outlining various ways in which electrodes can be conserved, when a representative of the manufacturer with the accumulation of electrodes asked to be heard.

The representative explained how the stubs were accumulated. The stubs, he said, resulted from a particular production job in which it is impossible to use more than 8 in. of a 14-in. electrode. With this job, the material to be welded is placed on a revolving, mechanically driven fixture. A new 14-in. electrode is desirable for starting this operation, since starting it with a partly used electrode means stopping the machine when the electrode is used, cleaning the weld, inserting a new electrode in the holder and starting the fixture again. Obviously, the representative pointed out, it is more economical to use a new electrode for each operation even though this results in an accumulation of large-size stubs.

Mr. Vom Steeg suggested that the manufacturer contact several welding schools, since these schools are finding it increasingly difficult to obtain electrodes for use in training war welders. Here a member of the New York Board of Education promptly offered to adopt the orphan stubs, explaining that they would prove invaluable in the city's manual training schools.

JOURNAL BOUND VOLUMES

Owing to increased size of JOURNAL, increased cost of production and increased cost of binding, it is necessary to change the prices of the bound volumes of the JOURNAL, effective April 1st. The prices will be $6.00 per volume, plus postage, to members; and $6.50 per volume, plus postage, to non-members.

ARMY-NAVY "E" AWARD

The El Segundo Plant of the Douglas Aircraft Company received the Army-Navy "E" Award for outstanding production of Dauntless Dive Bombers.

BUDD COMPANY EMPLOYEES AWARDED SECOND STAR IN ARMY-NAVY "E" PENNANTS

Renewal of the Army-Navy "E" Award to the employees of the Edward G. Budd Manufacturing Company with the privilege of adding a second white star to the company's war flag, has been granted by the Navy Board for Production Awards according to an accouncement made on February 25th. A new pennant with two stars has been presented to the company by the Commandant of the Fourth Naval District.

The Budd Company won its first war flag, the Navy "E" more than a year ago. This was followed by the Army-Navy "E" with one star. The latest award is the third given the company for its war production record.

When *Exceptional* Bearing Properties are Needed — *Wear-Resistant*

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THE *Only* COATED ALUMINUM BRONZE WELDING ROD

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Ampco-Trode coated-bronze electrodes are made in 7 grades of physical properties, giving a wide choice in strength and hardness.

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Superior Hardness and Strength. With a choice of seven grades with a wide range of hardness — 100 to 375 Brinell, you can select an electrode that will exactly meet your requirements; available also in tensile strength from 60,000 to 80,000 psi. Thus, instead of one electrode with a narrow range of properties, you have a series of electrodes from which to choose.

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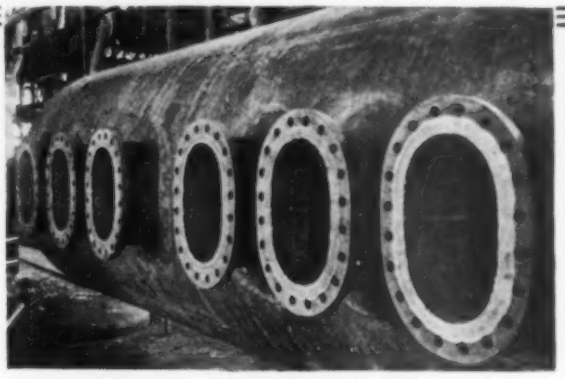


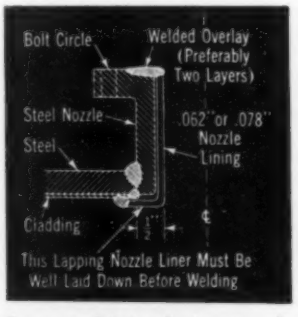
Fractionating tower, fabricated by Edge Moor Iron Wks., Inc. Diameter 6', overall length 43'6", top 15'6", section of Monel-clad 22/32" plate, cladding 1/8". Manways and covers also lined with 1/8" Monel, plug welded.

IN many important applications, the overlaying of Monel on steel permits maintaining continuous corrosion-resistant surfaces.

For example, in fabricating this fractionating tower of Lukens Monel-Clad steel plate, it enabled the manufacturer to protect the steel flanges with corrosion-resisting Monel. Thus, every part of the equipment which comes into contact with the harsh distillates resists their corrosive action.

Steel flanges are overlaid with Monel, first, by undercutting them 5/32" to 3/16" for a width of 1" or more, depending on the size of flange involved.

The first weld layer is deposited with 1/8" or 5/32" dia. No. 130X Monel electrode using string beads. Weaving is to be avoided because this technique makes a larger weld puddle . . . permits a higher percentage of iron to be diffused into the weld metal . . . lowers its corrosion resistance. Similarly, excessive penetration should also be avoided.



Suggested joint design, nozzle lining to sheet lining overlaying flange faces.

All flux should be removed from the first layer before depositing. Subsequent layers which may be laid down with a weave to produce beads up to 1/2" wide. Larger electrodes, 3/16" or 1/4", may now be used.

Monel overlays made with No. 130X electrodes on mild steel have a hardness of 150 to 160 Brinell (3000 kg.).

For full informaton on welding Monel, write for Bulletin T-2, "Welding, Brazing and Soft Soldering of Monel, Nickel and Inconel." The International Nickel Company, Inc., 67 Wall Street, New York, N. Y.

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Sheet . . . Strip . . . Rod . . . Tubing . . . Wire . . . Castings

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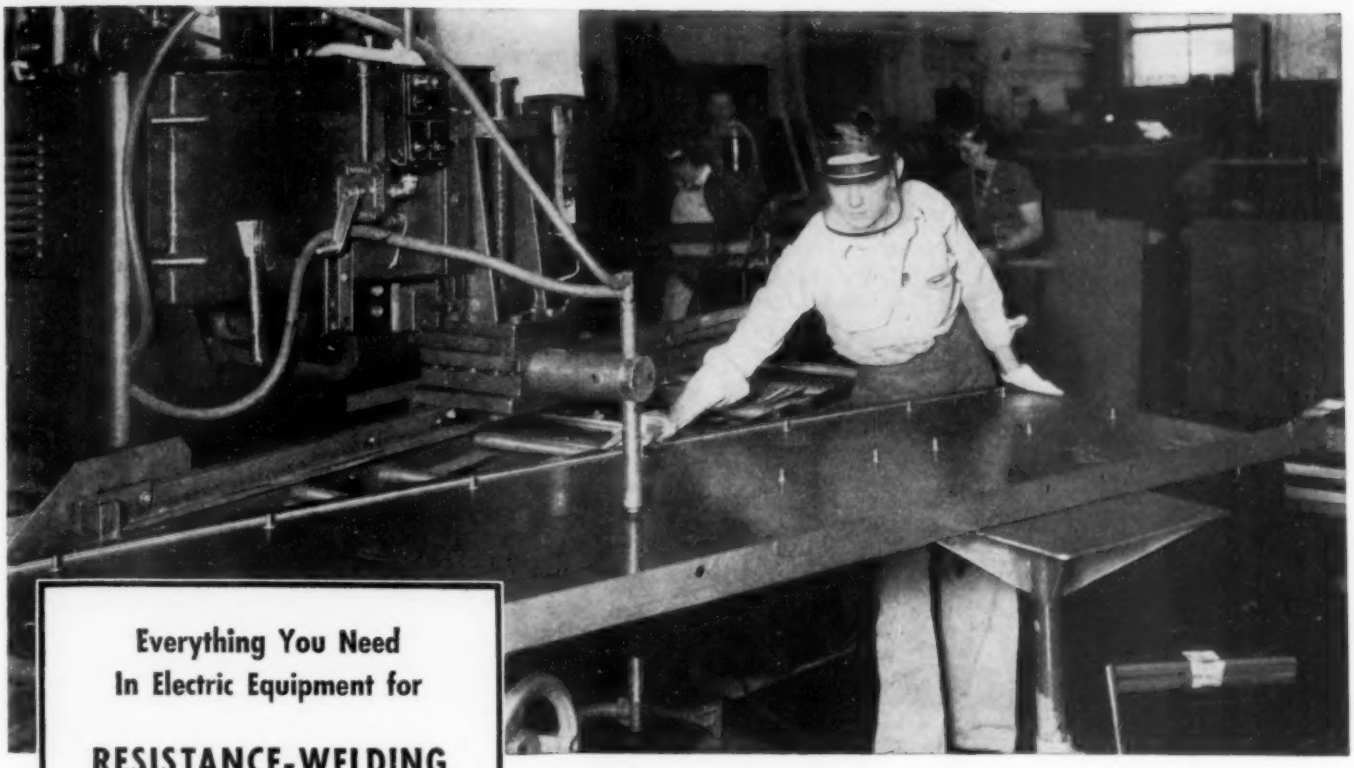

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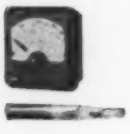
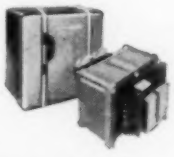


Cables and instruments



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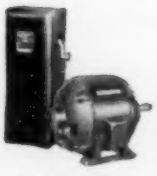

Motors and control

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SAVED 6 OPERATIONS

in Mounting These Studs

Today—

Insert a stud in the electrode and press the foot-switch. Before your foot returns to the floor, the weld is completed—strong, tough, *fast.* Stud and panel become *one piece* in *one operation.* Yesterday, before spot-welding took over, each stud took *seven operations.*

The Old Way—

Drill a hole, tap it, countersink it, screw in the stud, peen it (so it won't turn), grind off the rough surface, fill the stud head. *Seven* long steps. With 7 tools. But you can *spot-weld* a stud to that panel in the wink of an eye.

Resistance welding with precise electronic control is speeding the construction of light-metal and stainless-steel aircraft. Replaces soldering operations, too, saving tin and time. Joins like or unlike metals or alloys. Gives dependable, consistent results.

It makes gas-tight seams. Saves materials. Simplifies design problems. Relieves the shortage of skilled operators. Resistance welding is ideal for high-production operations on heavy or light work, portable or fixed, with men or women operators.

Whatever your application, be sure to specify G-E *electronic* control and electric accessories with your resistance-welding machine. For further information, contact any G-E office, your resistance-welding machine manufacturer or agent, or write Electronic Control Section, General Electric, Schenectady, N. Y.

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GENERAL ELECTRIC

SECOND PRODUCTION AWARD FOR HANDY & HARMAN

On February 20th at ceremonies held in the Handy & Harman Bridgeport plant, the company's employees were presented with an Army-Navy "E" Production Award for the second time and now have the honor of flying an "E" pennant with a "Star."

The "Star" Award Pennant was presented by Lt. Commander R. T. Fish, U.S.N.R., and was accepted for the company by Mr. G. H. Niemeyer, president, who in addition to expressing his gratitude told how silver and its alloys are doing important work in constructing ships, tanks, airplanes, guns, bombs, shells and other essential equipment.

SPOT WELDERS

New Bulletin P-50C has been published by the Pier Equipment Mfg. Co. of Benton Harbor, Mich., describing and illustrating their recently announced P-50 and P-100 Peer air-operated press type combination Projection and Spot Welders. Details of construction, equipment and application are included along with a chart of welding capacities for different gages of sheet and structural steel wire, rods and non-ferrous metals.

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Recognizing that the advent of women in industry presents a problem for specialized safety equipment, The Boyer-Campbell Company, Safety Division, Detroit, announces a catalog exclusively devoted to this purpose.

It describes equipment for the working girl's protection from head to foot, including clothing and caps by nationally known costume designers. But you will note that none of these styles has lost sight of protection—the primary motive of clothing for the factory.

WELDING BOOK

A new book, *The Instructor of Steel Arc Welding* by W. R. Stunkard, has been published by the author. Copies may be obtained at $3.00 per copy from W. R. Stunkard, 2015 Thirteenth Ave., Oakland, Calif.

The book contains 112 pages and is a course of instruction in steel arc welding. It is the story of successful welding gleaned from fifteen years of practical experience in a wide variety of work.

The book consists primarily of 25 lessons suitably illustrated and with appropriate questions at the end of each lesson.

RIEPPEL JOINS BATTELLE

Perry J. Rieppel, welding engineer, has been named to the research staff of Battelle Memorial Institute, Columbus, Ohio, where he will assist in welding research on industrial and governmental projects.

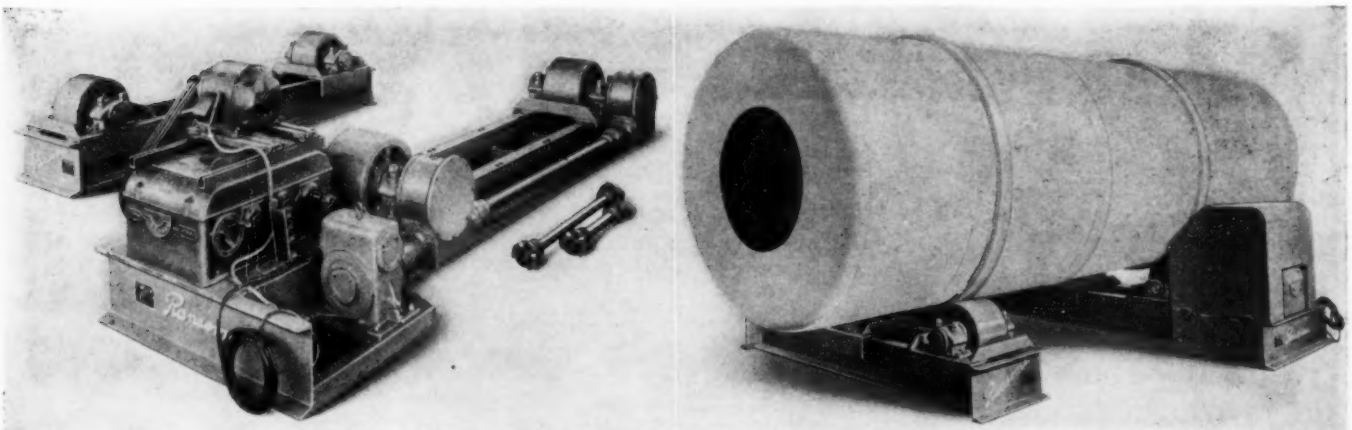
Prior to joining the Battelle staff, Mr. Rieppel was associated with the Buffalo plant of the Curtiss-Wright Corp. He is a graduate of Mansfield State Teachers College and has had additional work at Cornell University and the University of Buffalo. He is a member of the AMERICAN WELDING SOCIETY.

OXYACETYLENE FLAME ADJUSTMENT CHART

Prepared particularly for guidance of new welders, Airco's new color chart for oxyacetylene flame adjustment is being welcomed even by "old hands."

It shows natural color photographs of five fundamental flame adjustments: (1) acetylene burning in air; (2) a strongly carburizing flame; (3) slight excess of acetylene flame; (4) neutral flame; and (5) an oxidizing flame.

Being so completely graphic, it conveys the proper appearance of the various weld-



For Your Position-Welding Problem... RANSOME HAS THE ANSWER

This is the latest Ransome development in position welding equipment . . . . Turning rolls for rotating heavy cylindrical work.

The set of driving rolls is controlled by a variable-speed power unit. Means for adjustment to accommodate cylinders from 2-ft. to 14-ft. diameter is provided. One or more sets of idler rolls are used, according to the length of cylinder being worked.

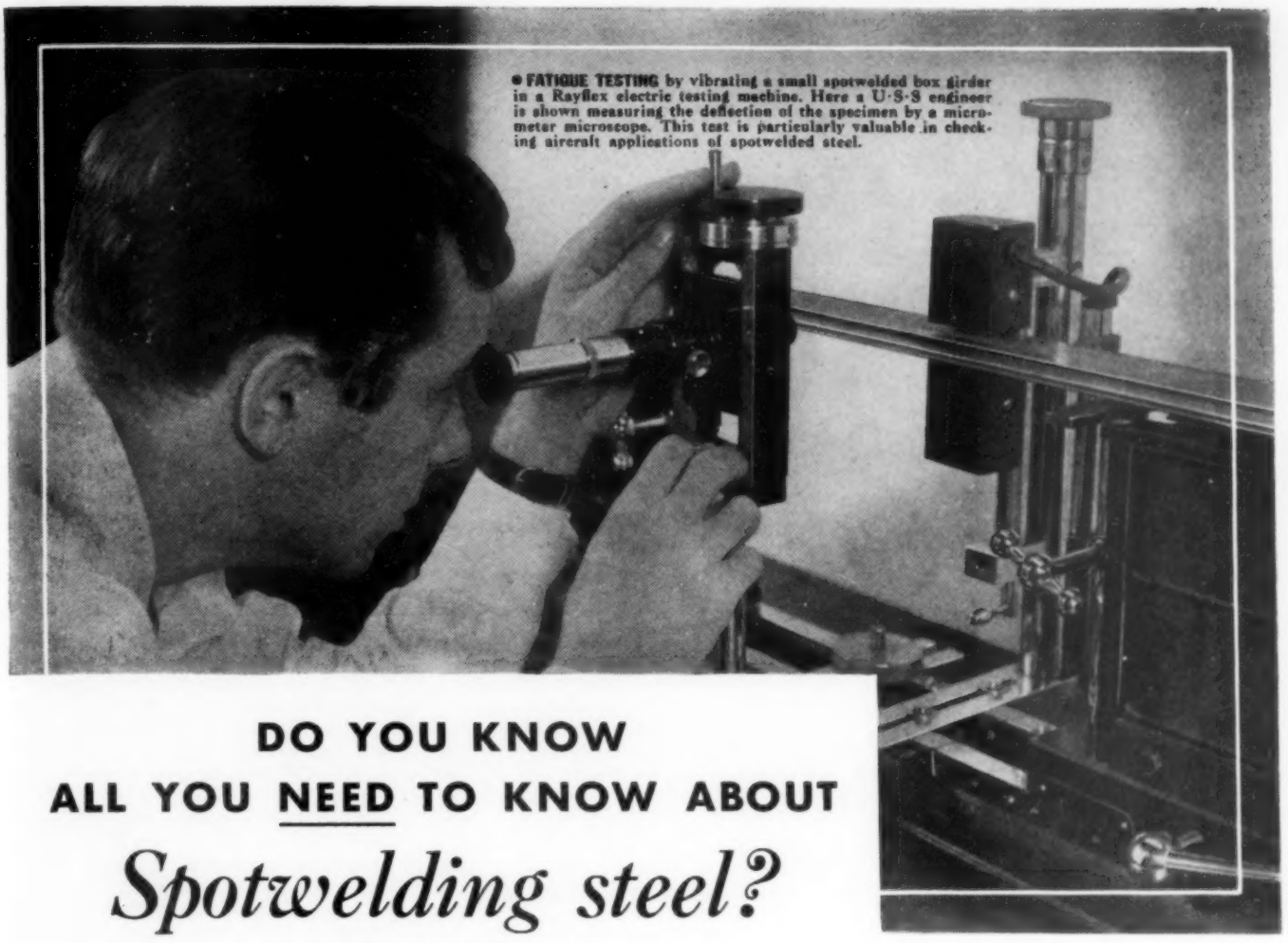
The Ransome line of positioners and rotating fixtures includes the unit that will help you produce smoother and stronger welds . . . . in less time than with old methods, and at a substantial reduction in cost.

Our engineers are ready to study your problem and to offer a specific solution.

» *Literature on request*

Ransome WELDING POSITIONERS

INDUSTRIAL DIVISION • RANSOME MACHINERY COMPANY • DUNELLEN, NEW JERSEY



● **FATIGUE TESTING** by vibrating a small spotwelded box girder in a Rayflex electric testing machine. Here a U·S·S engineer is shown measuring the deflection of the specimen by a micrometer microscope. This test is particularly valuable in checking aircraft applications of spotwelded steel.

DO YOU KNOW ALL YOU NEED TO KNOW ABOUT *Spotwelding steel?*

UNDER the pressure of war production, spotwelding is "growing up" too fast for anyone to know *all* about it. But if your plant is utilizing spotwelding to fabricate steel products, you need to know at least the best techniques for your particular application in order to meet quality specifications and production quotas.

We don't claim to know all about spotwelding steel. But U·S·S research engineers have accumulated one of the most complete sources of welding information available anywhere. Because we are the country's largest producers of steel, we have made it our job to understand the most successful methods for fabricating every type of steel.

For example, on one steel alone, Carnegie-Illinois engineers conducted an extensive test involving over 3000 spotwelded specimens. Its objectives were to determine the best welding techniques and to establish tension-shear strengths, pull-out strengths, angles of twist and impact values of spotwelds in this particular U·S·S Steel.

The results of this test and hundreds of others are available to provide you with accurate information on the spotwelding characteristics of any U·S·S Steel. There is no obligation. Simply write to us on your business letterhead, explaining your welding problem, and our engineers will suggest a solution based on practical research.

U·S·S Rolled Steels for Welding Include:

U·S·S High Tensile Steels to resist corrosion and increase strength without adding weight.

U·S·S Copper Steels to give twice the atmospheric corrosion resistance of regular steel at little additional cost.

U·S·S Abrasion-Resisting Steel to combat wear and friction.

U·S·S Stainless and Heat-Resisting Steels to assure high resistance to corrosion and heat, and to reduce weight.

U·S·S Carilloy Alloy Steels — Special steels for the special jobs of industry.

U·S·S Hot-Rolled and Cold-Rolled Steels to provide the basic advantages of steel, plus maximum economy in accordance with the requirements of each job.

U·S·S ROLLED STEELS FOR WELDING

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*

COLUMBIA STEEL COMPANY, *San Francisco*

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United States Steel Export Company, New York

UNITED STATES STEEL

ing flames faster and more accurately than any amount of descriptive instruction. This chart is a vitally important guide for every welder, for even the best manipulative welding skill is wasted unless flame adjustments are correct.

Desired quantities of these charts (which contain no advertising) may be obtained on request to Air Reduction Co., 60 E. 42nd St., New York, N. Y.

THE WELDING OF PIPING

"The Welding of Piping" is a practical treatise of 16 well-illustrated pages. Its material consists of a series of articles prepared by Air Reduction's Applied Engineering Dept.

It comprehensively covers various types of ferrous and non-ferrous piping, their dimensions, fabrication and estimates of welding and labor costs.

Copies may be procured on request to Air Reduction Co., 60 E. 42nd St., New York, N. Y.

CLASS OF WOMEN WELDING STUDENTS

The first class of women welding students ever graduated from the 25-year-old Lincoln School of Arc Welding, Lincoln Electric Company, Cleveland, Ohio, received diplomas Friday, January 29th. After teaching arc welding to more than 20,000 men, the school opened its first course to women on January 4th. Thirteen women completed the 4-week course.

The graduation exercises were held at the school as shown in the photo. The chief instructor, Arthur E. Madson (left), is shown holding the diplomas, while another instructor, M. O. McKenzie, is shown seated.

The first women graduates of the school are, left to right (front row), Mrs. Dorothy Brady, Mrs. Frances Burgner, Miss Marie Zanieska, Mrs. Anna Ferberdino, Mrs. Olive L. Wilcoxson, Miss Lena Grapo; (back row), Miss Helen Zanieska, Mrs. Olga Lang, Mrs. Stella Allin, Mrs. Irma J. Harmon, Miss Ellyn Sheptak, Miss Columbia Lucarelli.

Following graduation, the women accepted positions in various war plants in Cleveland. Among them were housewives, waitresses, and office workers.

FOUR DESTROYERS LAUNCHED

Four destroyers were launched at Kearny, N. J. on Sunday, February 28th, two at a time, in the shipyard of the Federal Shipbuilding and Dry Dock Company, bringing to five the number of destroyers launched by this single yard in February.

Federal is the holder of the first Army-Navy "E" presented anywhere, and the award has been renewed for "continued splendid achievement in outstanding production" of destroyers.

A Pearl Harbor hero's name was given one of the four ships, the destroyer *Kidd*, as it started down the ways of U. S. Steel's shipbuilding subsidiary. It was christened in honor of Rear Admiral Isaac Campbell Kidd, who was killed in action during the Japanese attack on Pearl Harbor, Territory of Hawaii, on December 7, 1941. The sponsor was his widow, Mrs. Kidd, of 31 College Ave., Annapolis, Md. Admiral Kidd was born March 26, 1884, in Cleveland, Ohio. The destroyers *Thorn*, *Bullard* and *Turner* likewise were named for distinguished naval men as they were sent into the water.

This was the third quadruple destroyer launching in the last ten months at the Kearny yard. The first quartet of sea fighters was sent down the ways, one at a time, last May 3rd in a total of fifty minutes. The second four were launched in twenty-eight minutes on Armistice Day, 1942, when the yard began the practice of launching destroyers two at a time. Telephones were used then as on this latest launching to signal the simultaneous start of two ships at a time down shipways in widely separated parts of the yard.

Ceremonies were confined to simple christenings because of wartime restrictions, which limited the spectators to guests invited by the sponsors.

MALLORY STANDARDIZED WELDING ELECTRODES

SPEEDIER PRODUCTION
LESS DOWN TIME
BETTER WELDING
LOWER COST

Whatever metals you're resistance welding . . . by spot, seam, flash or butt welding . . . specify Mallory Electrodes. They need redressing or replacement far less often. Write today for your *free* copy of the factual, up-to-date Mallory Resistance Welding Data Book.

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DID I DO THAT?

SMITHway WELDING MONITOR Trains Welders Better and 1/3 Faster; Saves Critical Material

Even a student welder is amazed at how quickly he learns to make difficult welds with the *SMITHway Welding Monitor.* Actual case histories prove that it not only trains welders better in one-third less time but also *reduces the electrode poundage* required for training from about sixty pounds to forty pounds per student — a *33⅓% saving in critical war material.*

Developed by A. O. Smith to meet our own needs in our own plants where thousands of tons of welded products are made each month, the *SMITHway Welding Monitor* is a device which automatically tells the student and the instructor when the electrode is being fed at correct speed, and when feeding speed is not correct. It is simple, easy to operate, inexpensive to buy, and pays for itself many times over in timesaving and in improved quality of welds. It will enable you to train more operators with fewer instructors — and quickly replace men taken by the draft.

HELPS INSTRUCTOR

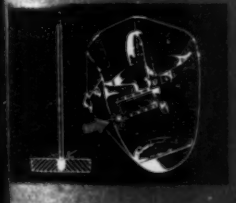
The Smith Welding Monitor enables the instructor to handle larger numbers of students. The Monitor is placed so that its lights are visible from a distance. They signal correct and incorrect welding as do the lights in the welder's shield. The instructor gives his attention where it is most needed.

MEETS REQUIREMENTS OF ALL TYPES OF ELECTRODES

Requirements of all of the various welding electrodes available today are met by the Smith Welding Monitor. Its dials are calibrated and the pointer merely has to be set on the value that has been found to be best for the particular electrode being used.

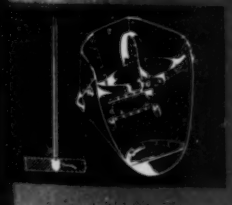
HOW IT SIGNALS OPERATOR

At the right and the left of the window in welder's shield are mounted miniature light bulbs which are connected to Monitor through a cable.



When the left-hand bulb glows, the operator immediately knows that the feeding speed is *too slow.*

When the right-hand bulb glows, the operator immediately knows that the feeding speed is *too fast.*



When neither bulb in the operator's shield is glowing, then feeding speed is *correct* and proper arc is being held.

SMITH Certified WELDING ELECTRODES

— *made* BY welders
— *FOR* welders

The Smith line includes (1) Mild Steel Electrodes, (2) High Tensile Electrodes, and (3) Stainless Steel Electrodes. Smith Laboratory Control positively assures *uniformity* between any box of electrodes purchased today and subsequent shipments of the same type.

SMITH A. C. ARC WELDER

A precision-built machine for precision welding, ruggedly constructed to carry heavy loads continuously without injury . . . 20% to 25% greater deposits than obtained with D.C. . . . *no arc blow* . . . light weight . . . compact . . . mobile . . . high efficiency . . . high power factor.

PRICE — $150 Net
F.O.B. MILWAUKEE, WIS.

This price includes Welding Monitor; plug connections and cable bulbs; also lighting assembly for mounting in your own helmet or hand shield.

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Milwaukee, Wisconsin

Please send us complete information about: ( ) Smith Welding Monitor; ( ) Smith Certified Welding Electrodes; ( ) Smith A. C. Arc Welder.

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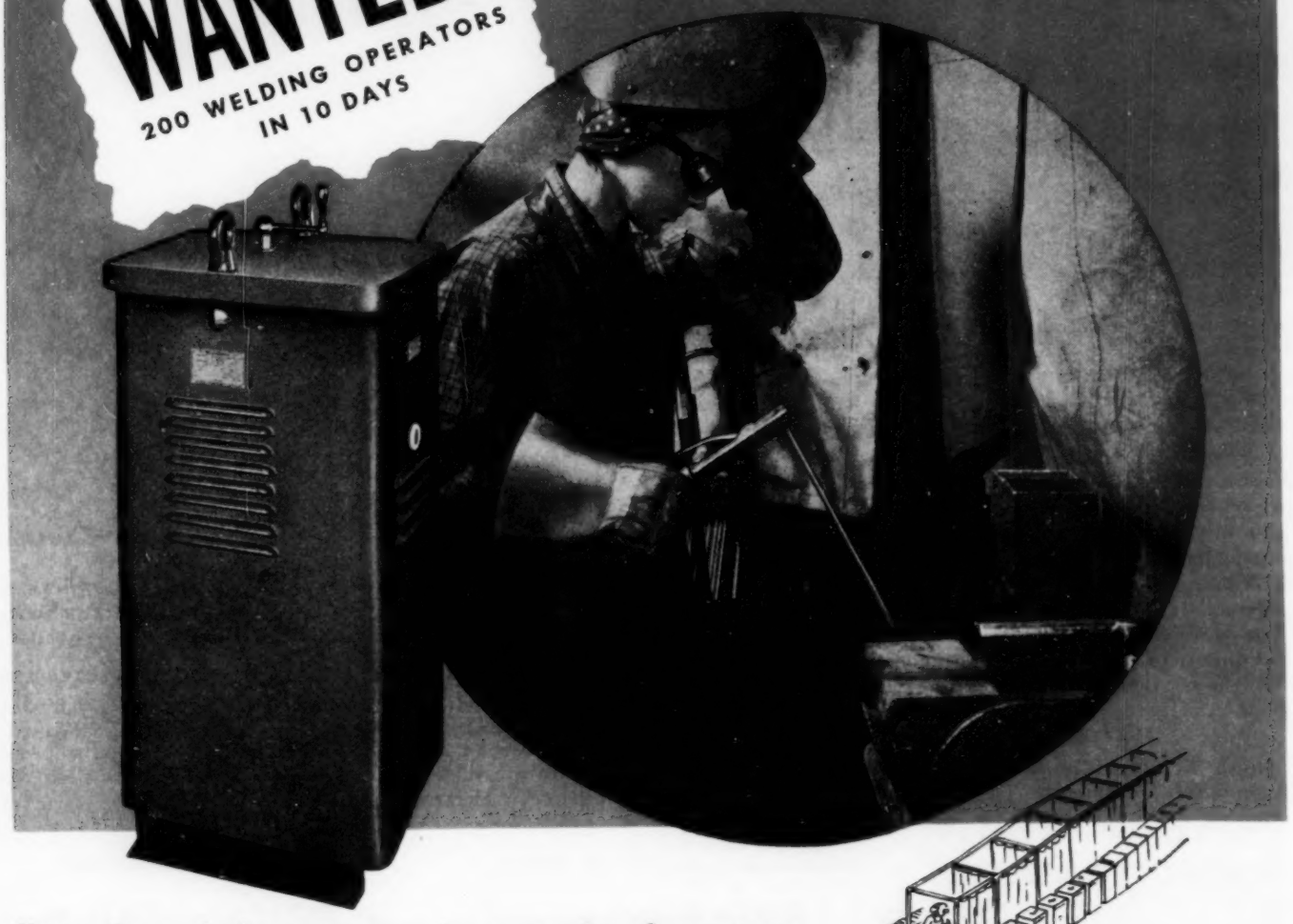
WANTED!

200 WELDING OPERATORS IN 10 DAYS

TANK TREAD SHOES, are now welded on assembly lines by women using Westinghouse a-c welders. Treads are positioned in jigs by helpers and swung into welding booths where 34 inches of downhand welding are applied to each.



"We found the answer in untrained women ... and A-C WELDERS," *says Chief Electrician of Large War Plant*

"Production-line welding in 10 days by women operators who never struck an arc before? A few days ago we would have thought it impossible. *Today, it's a fact!*"

So states this official, who has supervised the training of more than 600 women welders, for producing tank tread shoes on seven continuous production assembly lines. The average woman worker quickly learns how to strike an arc and run short beads—from then on she practices, practices, practices welding tank tread shoes. Usually in ten days she is ready for actual production welding (work must pass bend tests)—where her initial work is carefully supervised by her instructor.

"One of the biggest factors that has made it possible—and successful," says this electrical engineer, "has been the use of a-c welders. We bought them originally because they were immediately available, although we had always used d-c.

"We found, however, that the freedom from arc blow made it much easier to develop qualified operators. Weld quality is excellent. Most important, we've had literally no maintenance in nearly a year of 24-hour-a-day average operation."

★ ★ ★

The 275 Westinghouse a-c 500-ampere welders in operation at this plant are just a few of the many Westinghouse welders that are solving problems of availability, ease of operation and freedom from maintenance for many war plants. Ask for booklet B-3136. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

J-21269

Westinghouse A-C WELDERS

PLANTS IN 25 CITIES... OFFICES EVERYWHERE

BARNETT PROMOTED

Orville T. Barnett, Engineer of Tests for Murex arc-welding electrodes, of Metal & Thermit Corporation, New York, has been made Production Engineer for both arc-welding and Thermit welding divisions.

Mr. Barnett is a graduate of the Illinois Institute of Technology (formerly Armour Institute of Technology). Before joining Metal & Thermit Corporation, in 1940, he was connected with Black, Seville and Bryson of Oklahoma City, where he was in charge of welding and shop inspection.

In addition to his new duties, Mr. Barnett will continue to supervise quality control of welding electrode production at both Jersey City and East Chicago plants.

INDUSTRIAL RADIOLOGY

Industrial Radiology, X-Rays and Gamma Rays, by Ancel St. John and Herbert R. Isenburger. Second edition. Price $2.00. Published by John Wiley & Sons, Inc., New York. 298 pages. The present book is intended to furnish in readable form authoritative information concerning the practical use of radiology for industrial service. It presents not only the general principles governing the production and use of x-rays and gamma rays but also the special technique suitable for important classes of materials used by industry. To a great extent it represents the actual experience of the authors in the development and use of routine methods for rapid and economical inspection, in large-scale commercial operations. Some of this material is here published for the first time. Most of the curves and tables have been adapted from data available in the literature supplemented by private records. Wherever possible they have been expressed in forms immediately useful in the shop. Where curves, tables or illustrations have been taken directly, appropriate credit is given. For the convenience of those who may desire to pursue the subject more extensively, a bibliography of pertinent literature has been appended.

1942 BOOK OF A.S.T.M. STANDARDS, IN THREE PARTS

The recently completed *1942 Book of A.S.T.M. Standards*, issued in three parts, contains in their latest approved form all of the Society's widely used specifications and tests for materials, definitions and recommended practices. One of industry's most important books, the latest edition has 1090 specifications and standard methods which cover more than 4900 pages.

Continuing the policy first used with the 1939 book, the latest edition gives all specifications, whether formal standards or tentative. It is issued in three parts, the divisions being as follows:

Part I, Metals.—Ferrous and non-ferrous metals (all A and B and some E serial designations) except methods of chemical analysis. General testing methods (E serial designations).

Part II, Nonmetallic Materials—Constructional.—Cementitious materials, concrete and aggregates, masonry building units, ceramics, pipe and tile, thermal insulating materials (all C serial designations). Timber and timber preservatives, paints, varnishes and lacquers, road materials, waterproofing and roofing materials, soils (certain D serial designations). General testing methods, thermometers (E serial designations).

Part III, Nonmetallic Materials—General.—Fuels, petroleum products, electrical insulating materials, rubber, textiles, soaps and detergents, paper, plastics, water (remainder of D serial designations). General testing methods, thermometers (E serial designations).

The Society is also issuing a new edition of its volume of chemical analysis of metals, including 21 widely used standards for both ferrous and non-ferrous metals. This book will be issued later in 1943. These methods are not included in the Book of Standards.

Each part of the 1942 Book has a complete subject index. The Part II Index, for example, covers 32 pages, and there are two extensive tables of contents, the first lists all standards under general materials headings; the second lists them in order of the sequence of the serial designations. These features are intended to facilitate reference to any subjects covered. Some idea of the large increase in the books is indicated from comparative figures for the 1939 volume. (Publication of the books is triennial.)

1939— 866 standards—3700 pages
1942—1090 standards—4900 pages

1943–44 Supplements, Detailed Index

To keep the books up to date in 1943 and 1944, a supplement will be issued to *each* part in *each* of these years. As a service with the 1942 Book of Standards

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PRODUCTION
A-C WELDING

Whether it's a problem of training new operators quickly or of improving present weld quality, Westinghouse a-c welders, with their freedom from arc blow, can help you. 100, 200, 300 and 500-ampere models. Also 1000-ampere models for use with the Unionmelt process.

NEW
D-C WELDER with
ARCONTROL

Single, pre-set current adjustment. Lots of capacity to handle all kinds of work. No drop-off after warming up—less lost motion making adjustments. 200, 300, 400 amperes.

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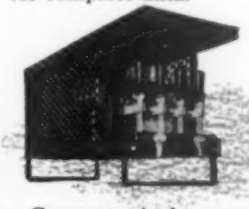
Do the work of 20 to 30 single-operator rotating sets. Stationary types for shop operation—semiportable types for use on shipways and similar applications. Ask for complete data.



PORTABLE
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Compact, single-operator control panels for fit-up work with multiple-operator sets. Extra capacity for light tack welding.

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WELDERS

there is a complete 200-page Index to Standards, which is furnished without additional charge and a copy accompanies the purchase of each part or complete set.

Sales Price, Including Supplements

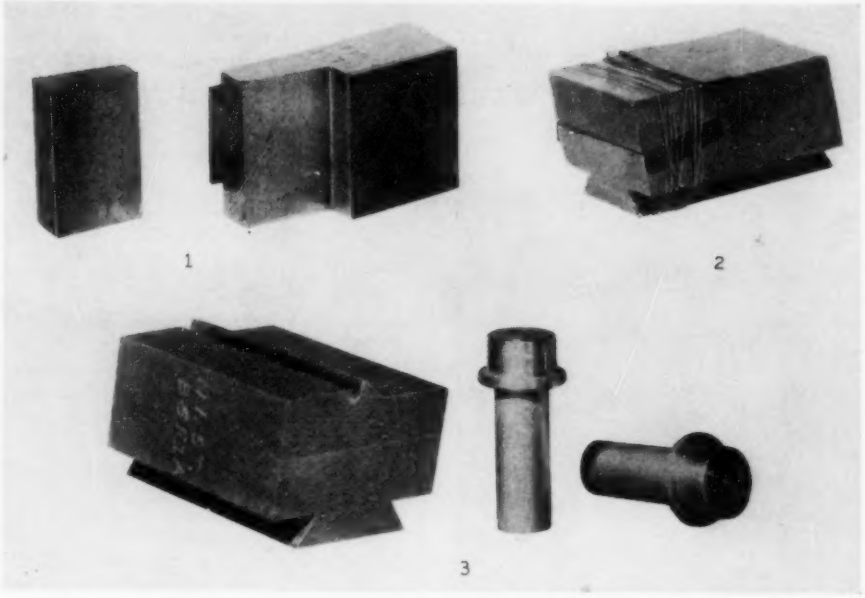
The cost of each Part is $9.00; the charge for Supplements is $3.00 for *each* part, *each* year. For half-leather binding add $1.00 extra for *each* part and each Supplement part.

Copies may be obtained from the American Society for Testing Materials, 260 South Broad St., Philadelphia, Pa.

BRAZING AND HARDENING HIGH-SPEED TIPPED TOOLS

Conservation of critical high-speed steel has been responsible for furnace brazing and hardening of high-speed steel tipped tools at General Electric's Schenectady Works. While the practice is not yet in full production, sufficient work has been done to predict its success.

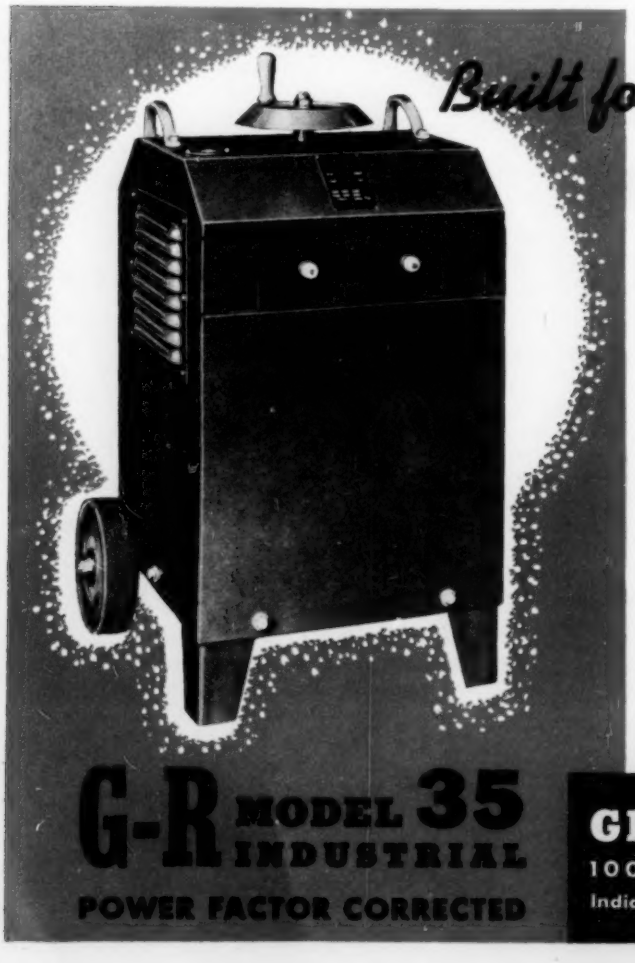
The tool blank is first rough machined and the part which has to be tipped is ground. The high-speed steel tool tip is then ground to meet the exact contour of the blank. This is to assure a definite all-over contact. The tip is then nickel plated and a 0.005-in. copper shim is inserted between the shank and tip. The tip is held in place with a piece of chrome-nickel wire. Both tip and shank are then covered with a suitable flux, and the tool is ready for brazing and hardening.



Dovetailed Forming Tool. 3 Views Showing: 1. High-Speed-Steel Tip and Nickel-Steel Shank; 2. Assembly Prepared for Furnace Brazing and Hardening; 3. Completed Tool and Work Produced with It.

This is done in a "controlled atmosphere" electric furnace, using drycolene, a gas developed for use in heat-treating furnaces. Steels that have been treated in this gas are free from surface changes such as decarburization, carburization and oxidation.

The brazing and hardening operations are done at and from the same temperature. The tool is put into the furnace without preheating. It is kept in the furnace long enough to heat up to a



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MAKING BETTER TIME— *There is still a shortage of welders skilled in specific jobs and many industries find they get on with their production program faster by "work-training" groups of men in the technique they must acquire to reach top production....As you check on your men, continue, also, to see that they use electrodes of correct analysis and size—see that they deposit no excess metal in the weld—make certain that they use the electrodes right down to the holder. With the tremendous increase in the use of welding electrodes it has become vital to stop waste*

PAGE WELDING ELECTRODES

PAGE STEEL AND WIRE DIVISION Monessen, Pa., Atlanta, Chicago, New York, Pittsburgh, San Francisco

---

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temperature of 2375° F. (if made from molybdenum steel 2250° F. is used). The tool is very carefully removed from the furnace so as not to disturb the tip. It is then quenched in oil until it turns black, approximately 1100° F., and then cooled in still air. The tool is then tempered two hours at 1050° F., air cooled and retempered one hour at 1050° F. and again air cooled. It is then finish ground.

Hardness tests of the high-speed steel tip indicate a hardness of 64-65 on the Rockwell "C" scale. While no complete life tests have been made on tools thus far, tests of forming tools on stainless steels at 120 surface-feet per minute have been very satisfactory. Several other tools, such as reamers, planing tools, dovetailed forming tools and cut-off tools are under test.

UNDERWATER RESISTANCE WELDING

At the East Pittsburgh works of the Westinghouse Electric & Manufacturing Co., underwater resistance welding has replaced many of the routine processes of soldering or brazing of standard copper cable to terminals. This modification of a standard welding process has saved considerably in production costs by raising output and improving the quality of finished products.

Essentially, the process consists of welding by means of special tips and having a stream of water playing on the stranded wire near the electrode. Water is applied at a volume sufficient to cool the work and prevent oxidation at the weld.

Machines for this work are usually designed with one fixed and one movable electrode with a special jig fastened around the stationary terminal to hold the parts firmly in their relative welding positions. Electrode tips as now used are made of carbon, molybdenum and cupaloy. Increased tip life is obtained by mounting them in water-cooled holders. For welds that do not require flux cupaloy tips with molybdenum inserts have been found most satisfactory. Carbon tips are required where flux is used. Inserts that contact the wire are grooved to prevent flattening the cable.

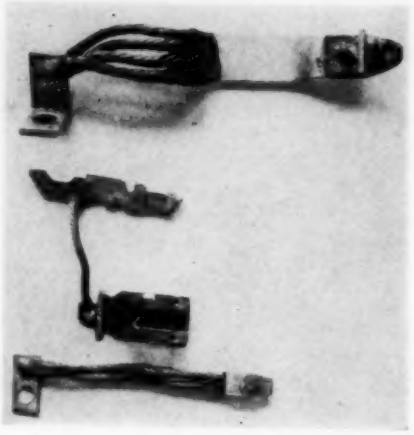

Fig. 1

By means of a foot pedal, the operator initiates the lowering of the upper electrode to complete the weld. The machine is air operated and is timed by electronic controls which insure a quality weld. The completed assembly may be removed immediately without the use of pliers or gloves.

Figure 1 shows typical welds made by this new process. With time values based on a 60-cycle basis and a small stream of water playing on the wire adjacent to the weld, the technical data for upper end of left-hand assembly are as follows: 2352 strands of 0.002 wire welded to 0.037-in. thickness of copper. Time 38 cycles, current 14,400 amp., 409-lb. electrode pressure. Cupaloy tips with molybdenum inserts on both top and bottom. The lower end of the assembly has the wire welded to two pieces of 0.020-in. thickness of tinned copper. Time required was 26 cycles with current of 14,400 amp. and 400-lb. electrode pressure. Flat surface tips used on both molybdenum inserts current and time are proportional to the size of the weld.

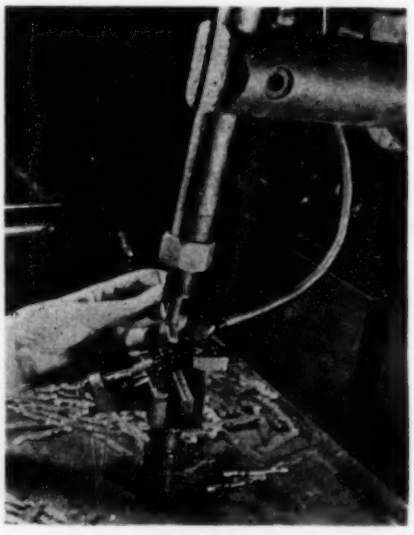

Fig. 2

This job, formerly a hand operation, is now a line production operation. Cost of production has decreased and quality and appearance of the completed parts have been vastly improved.

A noticeable comparison in completed assemblies by the old and new methods is that the wire cables remain flexible to the point of weld in the underwater resistance weld. In either the soldering or brazing process molten metal cools after being drawn into the hot cable by capillary action. Cooling the parts with water not only makes handling easier but heat is removed from immediate area of the weld rather than passing to more distant areas. Thus the original properties of the individual parts are not changed.

The savings and results of this process have made underwater resistance welding a standard part of quantity production.

NEW CHIEF METALLURGIST FOR TUBE TURNS

Tube Turns, of Louisville, Ky., announces the appointment of Fred C. Smith as chief metallurgist, effective January 18th.

From 1936 to the date of his present affiliation with Tube Turns, Mr. Smith was employed by Carnegie-Illinois Steel Co. at Chicago, in the capacity of field metallurgist. Prior to that he was plant metallurgist for the International Harvester Co. at Fort Wayne and Chicago plants.

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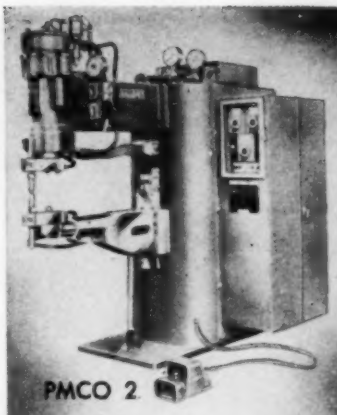
The Trade-Name is "ANTI-BORAX"

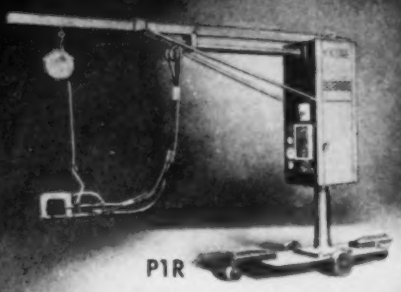
Ask for Them ***Unequalled for Quality***

A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10.

ANTI-BORAX COMPOUND COMPANY
Fort Wayne, Indiana



PMCO 2



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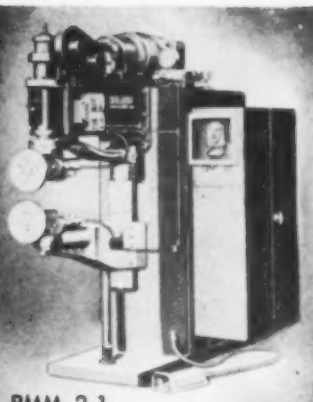
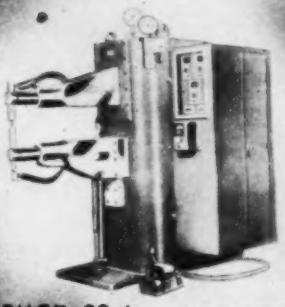
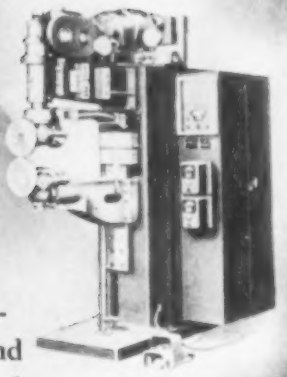


PMM 2-1



PMCR 2S-4

HERE THEY ARE A FEW OF THE SCIAKY RESISTANCE WELDING MACHINES THAT HELP GET THEM FLYING, SAILING AND ROLLING.



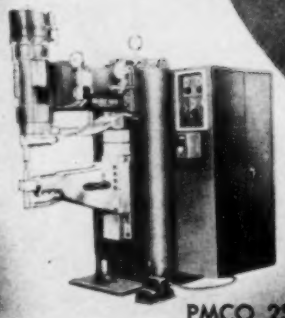
PMM 2S-1

These D.C. and A.C. machines weld aluminum, aluminum alloys, and magnesium metals .016″ plus .016″ to and including .187″ plus .187″ steel, mild steel, scaly steel, corrosion resisting steel, monel metals, inconel and other ferrous alloys from .012″ plus .012″ to and including .500″ plus .500″.

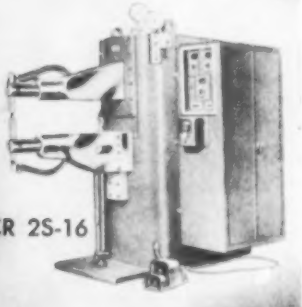
WHATEVER YOUR WELDING REQUIREMENTS MAY BE, THERE IS A SCIAKY WELDING MACHINE TO FIT THE JOB.

SCIAKY BROS.

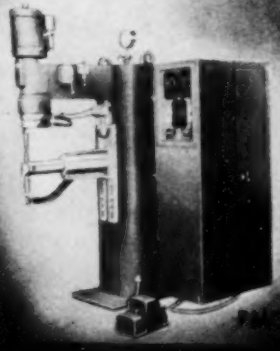
4915 WEST 67th STREET
CHICAGO, ILLINOIS

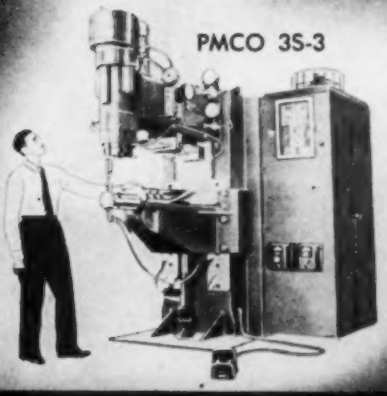


PMCO 2S-10



PMCR 2S-16





PMCO 3S-3

PMCO 2S-23

SCIAKY

PROCESS ELECTRIC RESISTANCE WELDING
STORED ENERGY · VARIABLE PRESSURE
WITH PREHEATING · WITH PRECOMPRESSION

Fred C. Smith

Mr. Smith is well known in the metallurgical fraternity. In May 1942 he was elected as vice-president of the American Society for Metals, which office he resigned when he came to Tube Turns. He is also a member of the American Society of Automotive Engineers and other technical organizations.

His responsibilities at Tube Turns include supervision of all raw- and finished-materials inspection, forging operations, heat treating and metallurgical research and service.

LIQUID COATING PREVENTS ADHESION OF WELDING SPATTER

After months of field testing under a wide variety of service conditions, The Midland Paint & Varnish Co. of Cleveland announce No-Spat, a liquid said to prevent adhesion of welding spatter. According to the manufacturer, No-Spat should be brushed over the seam and area where weld spatter may fall. After welding, the spatter may be wiped away, no chipping or grinding necessary.

For information write Midland Paint & Varnish Co., 9115 Reno Ave., Cleveland, Ohio.

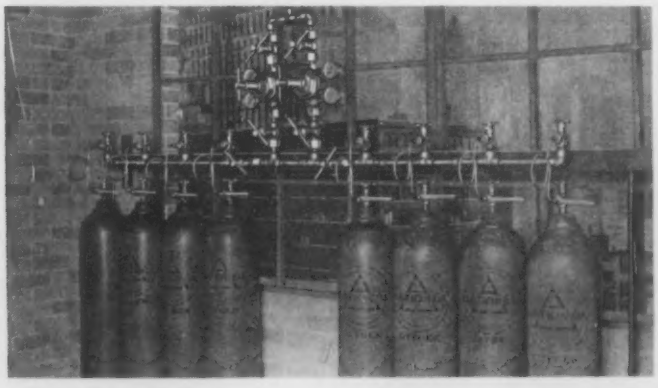
SUSTAINING MEMBERS

Eutectic Welding Alloys Company, 40 Worth St., New York, N. Y., originators and exclusive manufacturers of Castolin Eutectic Alloys for the Low Temperature Welding Process (for oxyacetylene, arc, furnace, high frequency, etc.). These materials can be used for production welding, salvaging, and reclamation of steel, cast iron, malleable iron, alloyed steel, tungsten carbide, bronze, brass, nickel, copper, aluminum, magnesium, die castings, etc. The process is suitable for joining, filling and for building up or surfacing. Free assistance and technical information upon request.

A. B. Farquhar Company, York, Pa., founded in 1856, has served America through four wars and now into the fifth, through the disturbance of booms and panics, and through it all has built a strong foundation. Today Farquhar is producing all types of war material for the armed services including such equipment as 81-mm. trench mortars and mounts, sterilizers and disinfectors, hydraulic production presses for smokeless powder, gun barrel straightening, cartridge case drawing, shell piercing and drawing, shell nosing and metal forging and extrusion. The largest of these is 7200 tons. This equipment requires all types of welding for complete fabrication. Farquhar also manufactuers the line of "Iron Age" farm implements and material handling "Portable" conveyors for coal and packaged goods.

SUSTAINING COMPANY

The Standard Oil Company of New Jersey refinery at Bayway, N. J., has been devoted almost 100% to the war effort since Pearl Harbor. At Bayway are the huge laboratories engaged in research work from which have come synthetic rubber, synthetic toluene for making TNT and 100-octane gasoline which enables our pilots to fly further and faster. Early this year a huge new fluid catalytic cracking plant was opened at Bayway which enabled the company to step up, to almost astronomical levels, the demand for these vital products originally developed by its laboratories.



BRASS MAKES BULLETS

REGO Gas Plant Equipment to be safe, must be made of brass and other critical metals.

Conserve equipment—You may not get more.

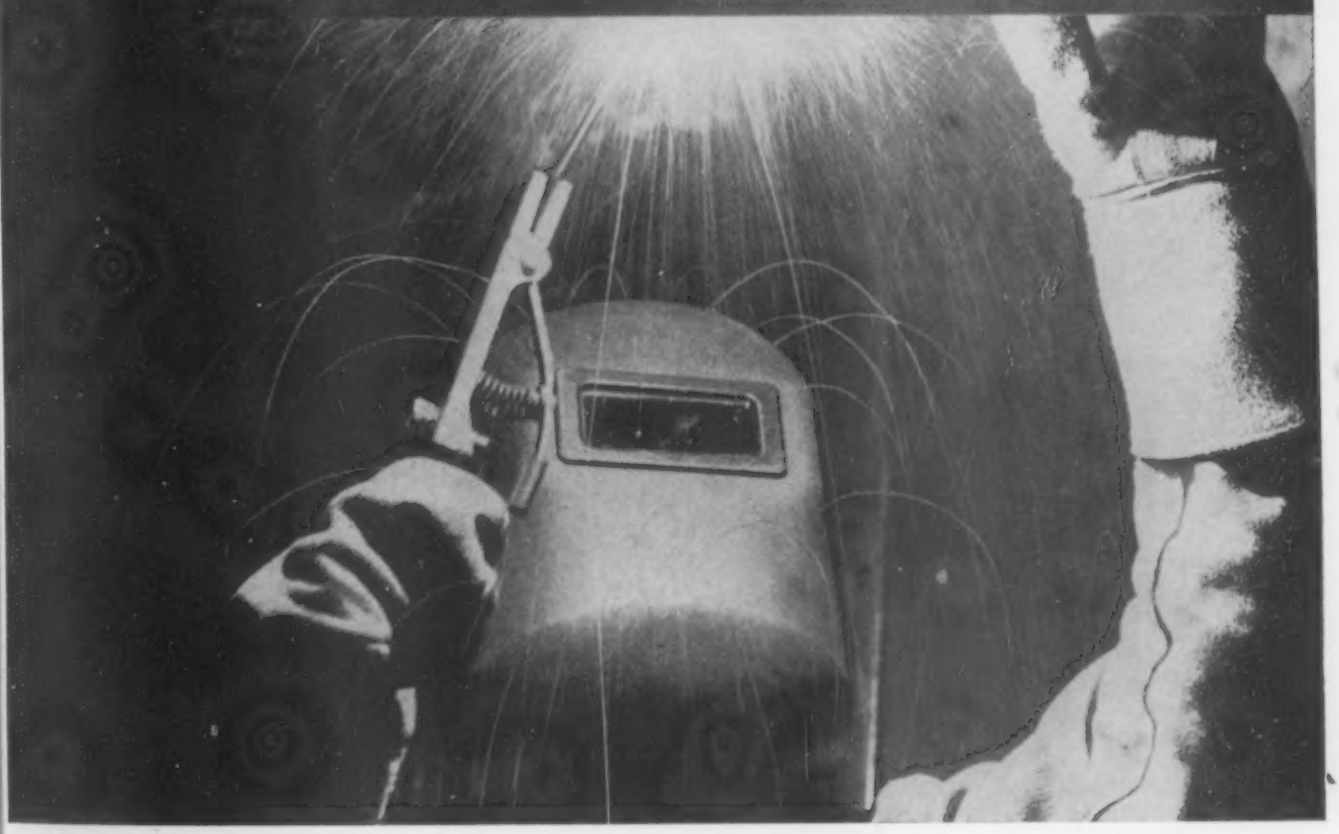
The BASTIAN-BLESSING Co.
4241 W. PETERSON AVE. CHICAGO
Pioneers and Manufacturers of Precision Equipment for Using and Controlling High Pressure Gases

Is this YOUR Cleaning Problem?
Degreasing Steel Parts Before Welding
Of all the factors that must be considered in welding steel plates, sheets, forgings, castings and parts, THOROUGH preliminary cleaning is one of the most essential. Oil, grease, drawing compound, heat scale or rust must be COMPLETELY removed . . . and WILL BE if you use safe, fast-working Oakite degreasing and descaling materials specially developed for this work.
Whether you're resistance, arc or gas welding, you'll find that Oakite surface preparation methods assure better, more uniform, stronger welds. Write today for helpful FREE data on your work.
OAKITE PRODUCTS, INC., 18E Thames St., NEW YORK
Technical Service Representatives Conveniently Located in All Principal Cities of the United States and Canada
OAKITE CLEANING

Don't Let Eye Fatigue Wreck Work Schedules

Provide your Welders with AO Helmets Equipped with

Filterweld Plates



Keep your workers *on the job* by providing them with easy-to-wear AO helmets—equipped with AO Filterweld, a service-proved welding plate, developed by American Optical Company Research Laboratories.

Filterweld* is obtainable without delay in shade Nos. 8, 9, 10, 11, 12 and 13. It is scientifically controlled in production with fixed standards of densities and conforms with U. S. Bureau of Standards Handbook H24.

Get in touch with your nearest AO Branch Office for American Welding Helmets, Hand Shields and Filterweld Plates.

*T. M. — Reg. U. S. Pat. Off.

American Optical

COMPANY

SOUTHBRIDGE, MASSACHUSETTS

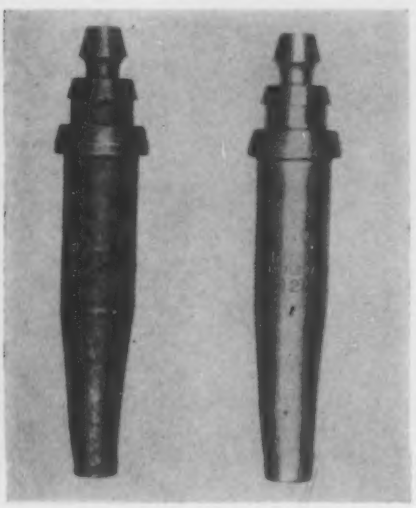
NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

MAINTENANCE ON GAS WELDING AND FLAME CUTTING TIPS

A time-saving method for maintaining brass or copper gas welding and flame cutting tips has recently been devised. After a period of normal use, tips acquire a deposit of carbon, slag, scale and tarnish. Orifices become congested or clogged, a condition which usually prevents utilization of correct pressures. When operating efficiency is thus affected, often gas is wasted.

With the new time-saving method, 500 tips are cleaned in three hours which cuts in half the time previously required for this work and more than doubles tip output. Quite important is the fact that the new technique now employed only requires the time of one individual, thus releasing the others for different work. Sequence of steps is as follows:



Tips are placed in basket and immersed in a boiling cleaning solution for from 45 min. to 1 hr., followed by cold rinse. Next, tips are immersed in solution of Oakite Compound No. 32 to remove carbon, slag and scale deposits, followed by cold rinse. Tips then are given a 10-min. bright dip followed by cold rinse and boiling rinse to dry down with final air blow. This sequence of operations takes approximately 90 min. after which tips are free of deposits that upset flame balance. Possibility of mechanical injury to tips such as may occur by using wire cleaners or drills is avoided and tips come out of solution clean, bright, looking like new inside and out.

Complete details concerning the new method prescribed and materials used are incorporated in a Special Service Report that may be obtained without obligation from Oakite Products, Inc., 18 E. Thames St., New York, N. Y.

ELECTRONIC HEAT

Electronic high-frequency induction heat has taken the place of gas heat in the soldering of crystal units used to maintain frequencies in war-radio equipment manufactured by the Electronics Department of the General Electric Company.

The crystal unit is placed in a fixture which locates it with respect to a two-turn inductor coil and a perforated air-blast ring nozzle. Heat is induced in the metal of the unit for a few seconds, after which a cooling air blast is operated for ten seconds. The entire sequence is automatically timed to assure uniform seals. During the heating cycle, the operator twists the shell slightly to assure uniform distribution of the solder.

In use, the part to be heated is placed in a water-cooled, copper tuning coil and current is passed through the coil at frequencies in the order of 500,000 cycles per second. This current generates the pulsating magnetic field which heats the part. The intervening air, or parts of the human body which may be in the magnetic field, are not affected.

BAR CUTTING IS SIMPLIFIED

Portable, oxyacetylene bar-cutting machines of this type are being used in various mills to square the ends of rolled bars, to remove etch-test specimens, to cut bars to length for shipment from the mill and to divide bars into lengths required for individual forgings. The machine requires neither electric power nor track on which to operate; it is positioned directly on the material to be cut, whether it be round or square bars. The cutting blowpipe is automatically guided along the contour of the bar by means of a swinging mechanism which is actuated by a self-contained hydraulic-power unit.

The accompanying illustration shows the machine being used to cut billets to shipping lengths.

Courtesy The Linde Air Products Co

HARD SURFACING OF WORN PARTS

Increased war production is taking its toll on plant machinery and equipment, thus wear and tear is rapidly increasing. Difficulties in replacing these worn parts result in a heavy demand for more efficient methods of salvaging. Those who have heard of the outstanding achievements in welding realized by the use of Castolin Eutectic Welding Alloys will welcome these new developments. The new Castolin DURFACE (*Dur*able Surfacing) line is designed for all-purpose rebuilding of worn parts and equipment at

low temperature, with high wear properties in the new added metal, thus enabling to prolong the life of vital material indefinitely.

PROJECTION AND SPOT WELDING

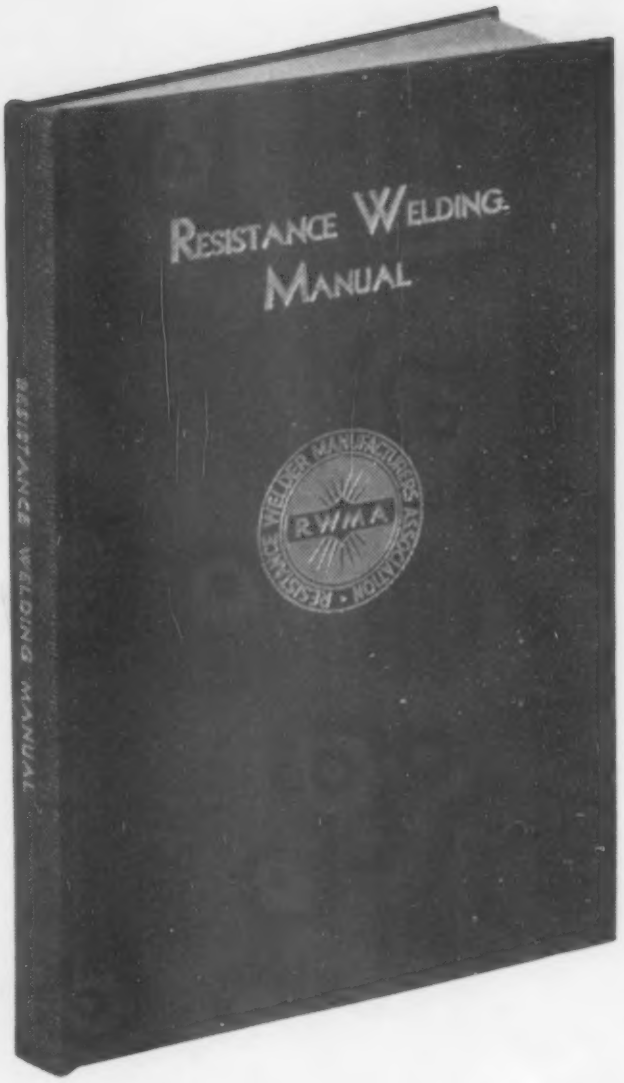
Series P-50 and P-100 automatic air-operated press type welders have recently been added to the electric welder line of the Pier Equipment Mfg. Co. of Benton

JUST PUBLISHED

The first and only

authoritative reference book

covering all phases of resistance welding exclusively.



6 Chapters
286 pages
205 tables, charts and illustrations

The RESISTANCE WELDING MANUAL was written and prepared by a group of resistance welding experts under the joint sponsorship of the Resistance Welder Manufacturers' Association and the American Welding Society.

All of the material in the book was originally included in the second (1942) edition of THE WELDING HANDBOOK published by the American Welding Society.

Realizing the urgent demand for resistance welding information and data, the Resistance Welder Manufacturers' Association, by arrangement with the American Welding Society, has now separately published all of the HANDBOOK material dealing with resistance welding. By this arrangement, it is now possible to obtain all of the resistance welding material without the necessity of securing the entire WELDING HANDBOOK.

This material has not been condensed or abridged in any manner.

Price $2.50 postpaid

THE RESISTANCE WELDER MANUFACTURERS' ASSOCIATION

505 ARCH STREET PHILADELPHIA, PENNSYLVANIA

Harbor, Mich. These welders are designed for high speed precision projection and general spot resistance welding of sheet and structural steel assemblies, wire and non-ferrous metals.

PEER P-100

Automatic Press Type Combination Projection and Spot Welder

They are equipped with double acting air cylinder and control valves to provide for smooth, speed action. Pressures depend on the size of cylinders and range from 800 to 4000 pounds readily adjustable by means of a regulating valve. Die platens with "T" slots hold projection welding dies, while for spot welding operation each welder is supplied with two 2½-in. diameter by 8-inch copper horns machined to accommodate 1¼-in. water-cooled electrode holders either at right angles or in offset position. Standard throat depths are 12 and 24 inches.

The series P-50, one of which is shown in the accompanying illustration, is made in two transformer capacities, 30 and 50; and the P-100 in 75, 100 and 150. The P-50's are supplied with either 4 or 5-in. cylinders with 6 and 8-in. for the P-100's. NEMA Types 1, 2 and 3 controls of welding timing and sequence are available, making almost limitless combinations of operations possible with little effort on the part of the operator.

EYE PROTECTION GLASS

Development of a new eye-protection glass—Didymium-Noviweld—which permits eyes of gas welders to pierce blinding glare and see welding operations from beginning to end, thereby increasing production of welded war equipment, is announced by the American Optical Company, Southbridge, Mass.

Previously, the glare of flame welding made it impossible for welders to see exactly what they were doing—a factor which has materially slowed up the welding of military planes, ships, tanks and other battle equipment.

Lenses made of the new glass possess all the ray-absorptive properties of American Optical's well-known Noviweld glass, plus the special characteristics of Didymium, a combination of elements with high absorption in that particular portion of the visible spectrum where "flux-flare" normally obstructs clear vision.

In all types of flame welding, the new Didymium-Noviweld safety goggle lenses cut down the high intensity sodium rays of the fluxes. Flame workers can thus look right through the yellowish cloud of "flux-flare," see the rod and the molten area more clearly, and thereby step up their efficiency in every phase of the welding operation, particularly the flame welding of aluminum and steel. The lenses

National

Carbide

IN THE RED DRUM

EFFICIENT

ECONOMICAL

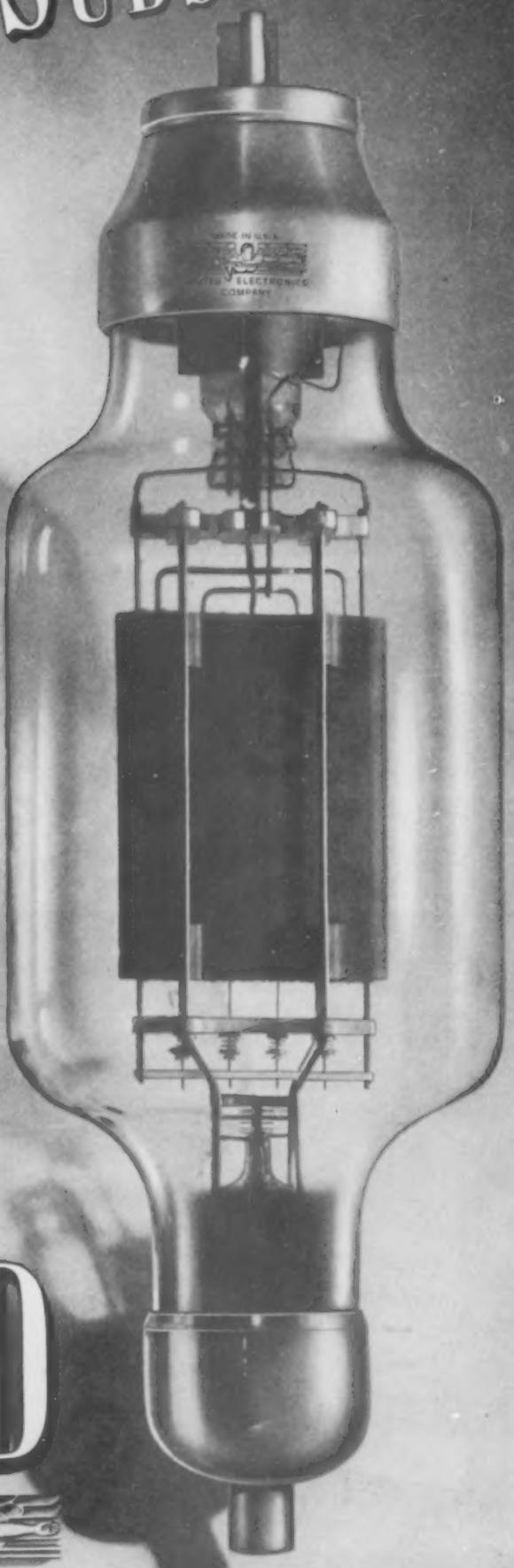
DEPENDABLE

FOR WELDING and CUTTING

Use National Carbide in the Red Drum

60 E. 42nd St. NATIONAL CARBIDE CORPORATION New York, N. Y.

SHADOW AND SUBSTANCE



In the highly specialized field of electronics, the question "Who made the tubes?" will always be a matter of vital importance. Power tubes bearing the name "United" are products of original pioneers in the miracle known today as electronics. Step by step these seasoned engineers helped evolve the principles and advance the science of fabricating transmitting tubes which hold a superb record of performance. The early pioneers at United are *still actively pioneering!* The wealth of experience which they have been privileged to accumulate under the demands of war will be available to you when "United" electronic tubes are available again on a peace-time scale for radio and industrial applications.

UNITED

ELECTRONICS COMPANY

NEWARK NEW JERSEY

also protect eyes by absorbing the harsh, tiring invisible ultraviolet and infrared rays generated during welding.

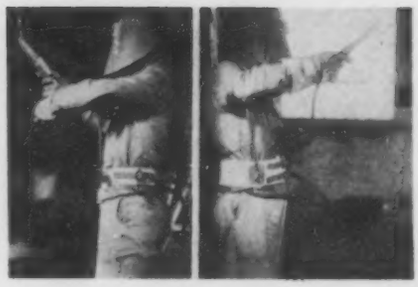
Noviweld-Didymium lenses are manufactured under strict laboratory control and meet the Bureau of Standards specifications for glare control. Three shades are available, numbers 4, 5 and 6 corresponding with shade numbers of the standard AO Noviweld lenses. Stocks are available for immediate delivery. Write American Optical Company for literature

GADGET FOR OVERHEAD WELDING

The gadget is simple and affords an easy rest for the operator who has to do overhead welding, chipping and burning.

The benefits of its use as explained by H. E. Gibson, the inventor, are as follows: First, by actual stop watch test, the average overhead welder wastes from $8^1/_2$ to 22 min. of each welding hour because of arm and shoulder fatigue. Second, without the rest longer rod stubs are discarded, increasing in length as fatigue sets in in proportion to the time spent in overhead welding. Third, a better and smoother weld because the arc is shorter and more steady.

The belt can be adjusted for either the right or left arm depending on the method used in welding and can be used by a right or left-hand operator. The accompanying photographs illustrate the two methods of use. Further information can be



secured by writing direct to Weld-Eze Ltd., Lunken Airport, Cincinnati, Ohio.

ACETYLENE GENERATOR

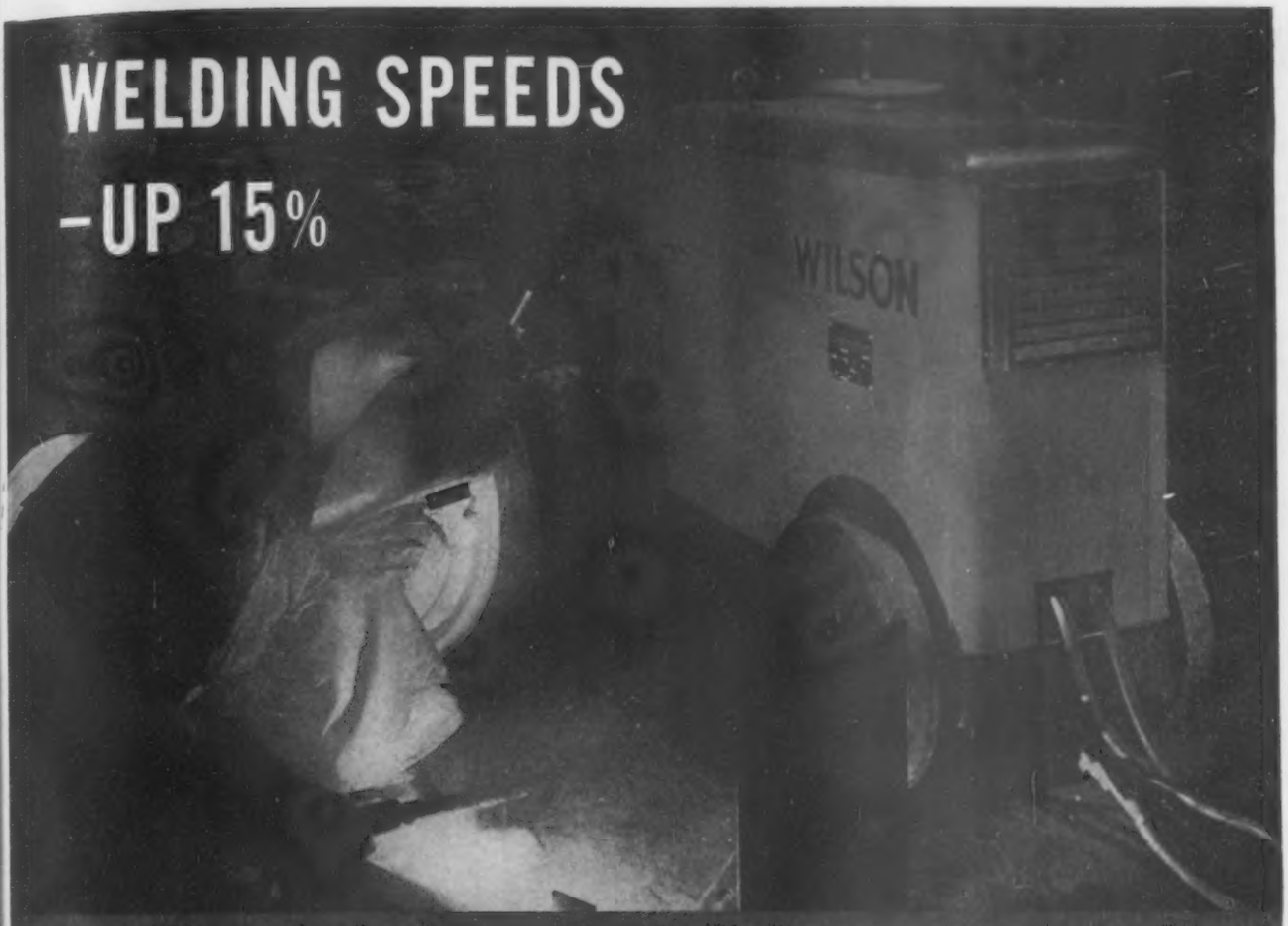
This generator is a portable high-pressure acetylene generator, new in the United States, but sold in Europe for a number of years. Principal features are automatic control obtained through the displacement method, employed with absolute safety in operation. The Adler Generator uses "lump" carbide ($3^1/_2$ x 2 in.) which is cheaper. Available for war industries in two convenient sizes—90 cu. ft. or 200 cu. ft. F.O.B. Milwaukee, Wis. Adler Manufacturing Co., 1440 N. 4th St., Milwaukee, Wis.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

The appointment of Carl H. Flink as technical secretary of the American Society of Heating and Ventilating Engineers has been announced by President M. F.

Miller AC Welders
SPEED PRODUCTION... LOWER COSTS
Miller AC Welders are available now in ten models for every shop and industrial need for BETTER WELDS at LOWER COST
● Here are some of the reasons why you speed up production and lower costs with Miller AC Welders:
1. It's faster to weld with Miller.
2. Miller AC welds are stronger.
3. You save on electrode costs.
4. Your power costs are lower.
5. Your installation cost is less.
6. You'll have no maintenance costs.
Write for full information about the advantages of Miller AC Welders
MILLER ELECTRIC MANUFACTURING CO.
Sales: Richmond, Indiana • Factory: Appleton, Wisconsin

WELDING SPEEDS -UP 15%



POWER CONSUMPTION–DOWN NEARLY 50%

WITH THE NEW WILSON "BUMBLE BEE" AC WELDING MACHINE

You can step up welding speeds 15% and better with the new Wilson "Bumble Bee" AC welding machine. This new AC welder permits use of larger electrodes and higher welding currents which provide faster metal deposition and fewer electrode changes. High quality welds are assured because there's virtually no troublesome "arc-blow" even when welding in deep grooves, corners, or similar difficult locations.

Power costs are reduced with a Wilson "Bumble Bee"—to almost 50% over DC machines of the same rating. Moreover, maintenance is easier because there are no heavy rotating parts requiring frequent attention.

Since the Wilson "Bumble Bee" uses only half as much copper and electrical sheet steel as DC machines, faster deliveries can be made at the present time. The "Bumble Bee" is made in two sizes —300 and 500 amperes. For full details on this new, improved AC welder, write to Wilson Welder & Metals Co., Inc., 60 East 42nd St., New York.

FOR HIGH QUALITY AC WELDING USE THE WILSON 530 ELECTRODE

A perfect teammate for the speedy Wilson "Bumble Bee" is the all position AC electrode—Wilson No. 530. This electrode produces high quality welds to meet the following specifications:

AWS Filler Metal Specification E6011
Navy Bureau of Ships, Specification 46E3, Grade III, Class 1
A.S.M.E. Boiler Code, Paragraph U68

WILSON

WILSON WELDER and METALS CO., INC.

General Offices: 60 East 42nd Street, New York, N. Y.

WILSON AC WELDERS — distributed exclusively through Air Reduction Sales Co.

Blankin. In this position Mr. Flink will be responsible for the coordination of technical committee work and assist in the compilation of codes and standards and work closely with the Guide Publication Committee in the preparation of this annual reference book of the Society. He will be at the headquarters office of the Society, 51 Madison Ave., New York.

Mr. Flink was born in Ironwood, Mich., and is a graduate of the University of Michigan with a B.M.E. degree in 1915.

During his 27 years of business and professional experience, he has been engaged in research and development work as chief engineer of the Institute of Thermal Research of the American Radiator Co., director of research for the American Gas Products Corp., and mechanical engineer in charge of product development laboratory of the American Radiator and Standard Sanitary Corp. His work included the development of equipment and tests of boilers, radiators, furnaces, air conditioners, oil and gas burners, hot water heating and control equipment.

Mr. Flink joined the A.S.H.V.E. in 1923 and the American Gas Association in 1927. He has had many committee assignments for both organizations and has participated in the development of codes and standards relating to coal-, oil- and gas-burning equipment.

He is a licensed professional engineer in the State of New York, a member of Tau Beta Pi, and during the first world war served with the Meteorological Division of the U. S. Army Signal Corps.

POLYTECHNIC INSTITUTE OF BROOKLYN

The Society of the Sigma Xi installed a chapter at the Polytechnic Institute of Brooklyn on March 25, 1943. The installation ceremonies were held in the afternoon, and will be followed by inspection of the laboratories. After dinner, a public address was given by Dr. Saul Dushman, Assistant Director of the General Electric Research Laboratory. This, the first public meeting of the new Polytechnic Chapter, was held in the auditorium of the Brooklyn Law School, 375 Pearl St., Brooklyn.

SUSTAINING MEMBER

The Ransome Machinery Company, Dunellen, N. J., manufacturers of a wide range of Welding Positioners used for position welding objects of many shapes, sizes and weights. Sales are handled through offices in some principle cities and direct from the Home Office.

SUSTAINING COMPANY

Alloy Fabricators, Incorporated, Division of Welin Davit & Boat Corporation, Perth Amboy, N. J., manufacturers of welded stainless and alloy steel equipment, such as: pressure and storage vessels, fractionating columns, mixing equipment, kettles, dye tanks, stills, tubular apparatus, chemical process equipment, welded pipe fittings, return bends, weld ells, van stone laps, welded tubing and pipe $2^1/_2$ in. diameter and larger in commercial lengths

WELDING AND BRAZING

Conference, under the auspices of the American Institute of Electrical Engineers April 9—9-00 A.M., Berkshire Museum Auditorium, Pittsfield, Massachusetts.

E. F. Potter, General Electric Company, will compare the efficiency, speed, and quality obtainable by A-C and D-C arc welding.

R. F. Wyer, General Electric Company, will discuss problems resulting from A-C welding applications from the viewpoint of the public utility.

H. L. Palmer, General Electric Company, will describe developments in resistance welding control that are of importance in the war effort.

Dr. W. F. Hess of Rensselaer Polytechnic Institute will speak upon the "Control Requirements for Spot Welding of Hardenable Alloy Steels in Light and Heavy Gages."

W. C. Reed, General Electric Company, will describe the process of electric brazing, the equipment and fluxes used and the results obtained.

At the conclusion of these prepared talks, the meeting will be open for general discussion.

LESS CRITICAL WELDING CONTROLS

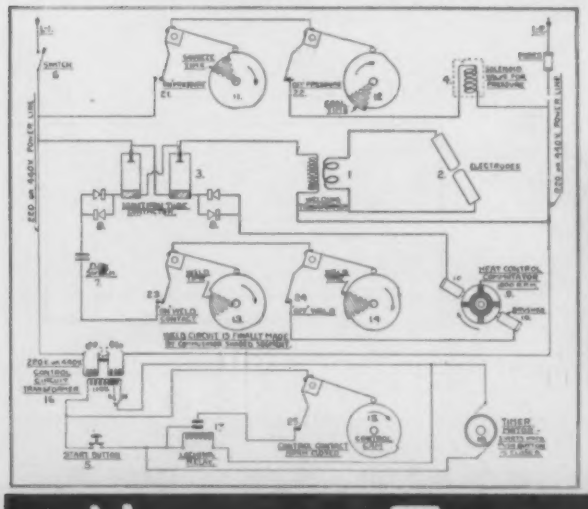
can PREVENT POSSIBLE MACHINE SHUT-DOWN.

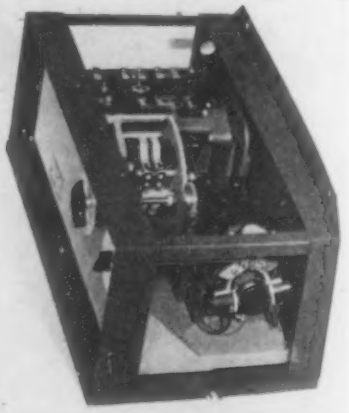
The Tube Situation is REALLY Serious.

NATIONAL WELD-TIMERS WILL PULL YOU THROUGH, and SOLVE YOUR WELDING HEADACHES.

DUO-TROL, the PRECISION SPOT WELD TIMER, does Equally Well on ALCLAD or STAINLESS.

Dial Control — for Pressure-Weld-Time and Heat Control — All in One Unit. Forge Control Optional.





Side view of DUO-TROL with cover removed. A compact unit weighing but 30 pounds. Easily attached to any Welding machine using Ignitron Tube Contactors.

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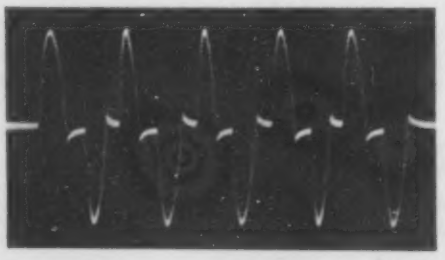

A 5 Cycle Oscillogram of Weld Current, showing Heat Control, or Delayed Firing.

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Devin, Emmanuel O. (D), 25 Chester St., Allston, Mass.
Driscoll, Everett (D), 234 Norfolk St., Wollaston, Mass.
Faustini, Philip J. (D), 242 Hayward St., E. Braintree, Mass.
Frost, Herbert O. (D), 50 Gloucester St., Boston, Mass.
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Johnson, Thure A. (C), Mass. Engrg. Co., 15 Fayette St., N. Quincy, Mass.
Kelly, Raymond G. (D), 6 Gordon St., Jamaica Plain, Mass.
Muldoon, Joseph R. (D), 11 Abbott St., Lowell, Mass.
Murphy, Harry J. (C), Mass. Engrg. Co., 15 Fayette St., N. Quincy, Mass.
Schauweker, George H. (C), American Optical Co., Southbridge, Mass.

CANADA

Polley, Jack (C), 10 Afton Ave., Toronto, Ont., Canada.

CHICAGO

Blodgett, F. L. (C), C. E. Phillips & Co., 332 S. Jefferson St., Chicago, Ill.
Hoekstra, A. R. (B), 10564 State St., Chicago, Ill.
Kairys, John (D), 5959 S. Keeler Ave., Chicago, Ill.
Reiser, Leo (B), 238 N. Pine St., Chicago, Ill.
Steele, Melba E. (D), 4054 W. Monroe St., Chicago, Ill.

CINCINNATI

Beckman, E. F. (C), 3837 Borden St., Cincinnati, Ohio.
Fitzwater, J. E. (B), International Harvester Co., Springfield, Ohio.
Glass, Justis (D), Deer Park, Ohio.
Maescher, Clifford G. (C), 572 Terrace Ave., Cincinnati, Ohio.
Pahner, Wm. F. (C), R. R. 1, Box 45 A, Sharonville, Ohio.
Swicher, Keith A. (D), 615 E. Pearl St., Miamisburg, Ohio.

CLEVELAND

Briers, Eugene H. (B), Firestone Steel Prods. Co., Firestone Pkwy., Akron, Ohio.
Fassnacht, Milton E. (C), National Cylinder Gas Co., 3965 Jennings Rd., Cleveland, Ohio.
Hinger, Roy E. (C), 8995 Ann Court, Cleveland, Ohio.
Le Vally, K. S. (C), 3256 Cedarbrook Rd., Cleveland Hgts., Ohio.
Manzel, Joseph (C), 10308 Nelson Ave., Cleveland, Ohio.
Marisch, Fred (B), 2019 Lakeland Ave., Lakewood, Ohio.
Ridenour, J. F. (B), Standard Oil Co., Midland Bldg., Cleveland, Ohio.
Schuster, Fred (D), Kroger Grocery & Baking Co., 5700 Truscon Ave., Cleveland, Ohio.
Turk, Earl E. (C), 16104 W. Park Rd., Cleveland, Ohio.

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Jones, David O. (D), 1147 S. Washington Ave., Columbus, Ohio.
Klein, U. M. (D), 815 Siebert St., Columbus, Ohio.
Leser, Wm. E. (F), 761 Henry St., Marion, Ohio.
Spurrier, C. L. (B), The Ohio Power Co., Philo, Ohio.

CONNECTICUT

Brennan, Francis H. (C), Geer St., Cromwell, Conn.

DETROIT

Adams, Robert (C), 741 Seward Ave., Detroit, Mich.
Cascioli, Matthew (C), 5117 University, Detroit, Mich.
Cobb, Lee S. (D), 1030 Remington Ave., Flint, Mich.
Farmer, Rex L. (B), 19721 Riopelle, Detroit, Mich.
Furnival, William (C), 4222 Gray, Detroit, Mich.
Henkle, Allan E. (B), 960 W. Willis, Detroit, Mich.
Huber, John F. (B), 606 E. Marengo, Flint, Mich.
Jessop, Henry (B), 807 Fernwood Rd., Royal Oak, Mich.
Keck, Karl G. (B), 231 E. Troy, Ferndale, Mich.
Lawrence, Frank J. (C), 1715 Caniff, Hamtramck, Mich.
Le Blanc, Fred (B), Orchard Trailer Park, Flint, Mich.
Less, Albert A. (B), 617 E. Eldridge Ave., Flint, Mich.
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Middaugh, Martin C. (C), 4040—4th St., Detroit, Mich.
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Tromans, Harold (C), 1919 Geneva Ave., Detroit, Mich.
Warden, Jack Pen (C), 5011 Steadman, Dearborn, Mich.
Wartman, Evelyn (C), 361 E. Dayton St., Flint, Mich.

INDIANA

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Knight, Alvah E. (D), 11338 Bessemer, N. Hollywood, Calif.
Larsen, Walt (D), 101–1035 D Walk, Wilmington, Calif.
Le Blanc, Harold (C), 513 S. Pannes St. Compton, Calif.
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De Lotto Severino (D), 195 Christie Ave., Clifton, N. J.
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Maguire, E. L. (B), Alloy Fabricators, Inc., 500 Market St., Perth Amboy, N. J.
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Pieters, Leonard (D), R.F.D. 1, Newfoundland, N. J.
Prince, H. L. (C), Alloy Fabricators, Inc., 500 Market St., Perth Amboy, N. J.
Pursell, R. (B), Worthington Pump & Machy. Corp., Harrison, N. J.
Quinlan, F. (B), Worthington Pump & Machy Corp., Harrison, N. J.
Seazholtz, John (D), 20 Campbell Ave., Belleville, N. J.
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Smith, T. B. (A), Federal Shipbldg. & Dry Dock Co., Kearny, N. J.
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Tullo, C. (B), Worthington Pump & Machy. Corp., Harrison, N. J.
Wright, E. F. (B), Worthington Pump & Machy. Corp., Harrison, N. J.
Wyman, H. F. (B), Alloy Fabricators, Inc., 500 Market St., Perth Amboy, N. J.
Yurasko, Frank H. (B), 156—8th Ave., W., Roselle, N. J.

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Lannier, Wm. (D), 150 Brandywine Ave., Schenectady, N. Y.
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Scibner, Rupert O. (D), 53 Columbia St., Schenectady, N. Y.
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Smith, E. D. (D), Box 505, Eufaula, Okla.

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De Long, Duane (C), 513 W. Corrington Ave., Peoria, Ill.

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Israel, Harry C. (D), 328 E. Patterson, Lansford, Pa.
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Kier, Melvin A. (C), Ewan, N. J.
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Wysocki, Harry M. (C), 1121 Atlantic Ave., Camden, N. J.
Zimmerman, Frank W. (C), 3 Ewing Rd., Trenton, N. J.

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Conrad, Andrew (D), 721 Brighton Rd., N. S., Pittsburgh, Pa.
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Nelson, Merrill A. (C), Nelson's Garage & Welding, Wayne & Chestnut, Butler, Pa.
Stier, H. Clay (B), United Tube Corp., P. O. Box 311, Ellwood City, Pa.

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Kennedy, Harry E. (B), 18 Yale Circle, Berkeley, Calif.
Perkins, A. W. (D), 18½ S. Church St., Lodi, Calif.
Robbins, Lawrence (D), 3028 Irwin St., Vallejo, Calif.
Stapel, A. O. (D), 3600 Lincoln Ave., Oakland, Calif.

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Pavlu, Albert (D), Hallettsville, Tex.
Rainbolt, Gordon (D), 217 N. Super, Houston, Tex.
Rollins, Chummy (C), P. O. Box 1068, Beaumont, Tex.

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Walten, Max (B), 1628 Webster St., N. W., Washington, D. C.

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Williams, Floyd R. (D), 44 Shenandoah Rd., Buffalo, N. Y.

WICHITA

Sutton, O. A. (B), Aircraft Welders, Inc., 403 Beacon Bldg., Wichita, Kan.

YOUNGSTOWN

Blystone, Reid (D), 126 Milton Ave., Youngstown, Ohio.
Jamison, Carroll (D), 1311 Rigby St., Youngstown, Ohio.
Williams, John H. (D), 623 Chestnut St., Columbia, Pa.

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Absher, Richard R. (B), 5931 Madison Ave., Newport News, Va.
Bibic, Edward (D), % Hopkins Equip Co., Hatfield, Pa.
Brown, James L. (B), Marsh Foundation School, Trades & Industries Dept., Van Wert, Ohio.
Burton, Fred M. (C), Burton Saw & Supply Co., Box 302, Eugene, Ore.
Carlson, Roy S. (D), R. D. 3, Edinboro, Pa.
Gumm, Eugene C. (C), R. 4, Box 4, Louisville, Ky.
Handy, Harry E. (B), The Ohio Oil Co., Robinson, Ill.
Hayner, John L. (B), Fort Wayne Structural Steel Co., 4920 N. Clinton St., Fort Wayne, Ind.
Hinnant, Blenn (D), Box 82, Kenly, N. C.
Hodges, Harold (D), Joplin, Montana
Jarski, Joseph T. (D), 1102 East Ave., Erie, Pa.
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Koman, John (D), R. D. 4, Edinboro, Pa.
Leonard, Herbert C. (C), 191 Leonard St., Acushnet, Mass.
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Miller, John D. (D), General Auto Service, P. O. Box 504, Luray, Va.
Muenz, Robert (D), R. D. 1, Kelso Dr., Erie, Pa.
Ostrowski, John J. (D), 527 E. 5th St., Erie, Pa.
Salisbury, Marion C. (C), Rt. 2, Box 105-B, Tillamook, Ore.
Schmidtman, Lt. Cmdr. Richard D. (B), Chief Inspector, U.S.C.G., Toledo Shipbldg. Co., Toledo, Ohio.
Short, Max R. (D), R. D. 1, McKean, Pa.
Sias, Gerald Thomas (D), 4101 Maxwell Ave., Erie, Pa.
Smyers, Greable W. (D), Trailer Camp, E. Lake Rd., Erie, Pa.
Szeman, Joseph W. (C), 2066 W. 20th St., Erie, Pa.
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Wolf, Frank J. (B), Gardex, Inc., 423 E Second St., Michigan City, Ind.

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Nelson, Paul G. (from D to C), 709 Church Lane, Germantown, Philadelphia, Pa.

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Farrer, P. M. (from D to C), Concord, Calif.
Rendall, Chester L. (from D to C), 1485 Vallejo St., San Francisco, Calif.

YORK-CENTRAL PENNA.

Burket, Adam H. (from D to C), 44 W. Liberty St., Lancaster, Pa.

SECTION ACTIVITIES

BOSTON

Mr. J. G. Magrath, Engineer, Applied Engineering Dept., Air Reduction Sales Co., spoke at the March 8th meeting of the Section on "Welding and Cutting at Modern West Coast Shipyards." Using many slides, Mr. Magrath showed how important oxyacetylene cutting and arc welding are in modern merchant ship building. His talk and slides covered the layout of modern shipyards, systems for oxygen and acetylene distribution, the training of welders and cutters, uses of cutting and welding equipment in the assembly shops, pipe and machine shops, and in the yard. Mass production of Liberty ships from keel to launching was shown in the slides.

The annual meeting of the Section is scheduled for April 12th at the Engineers' Club, Boston.

CHICAGO

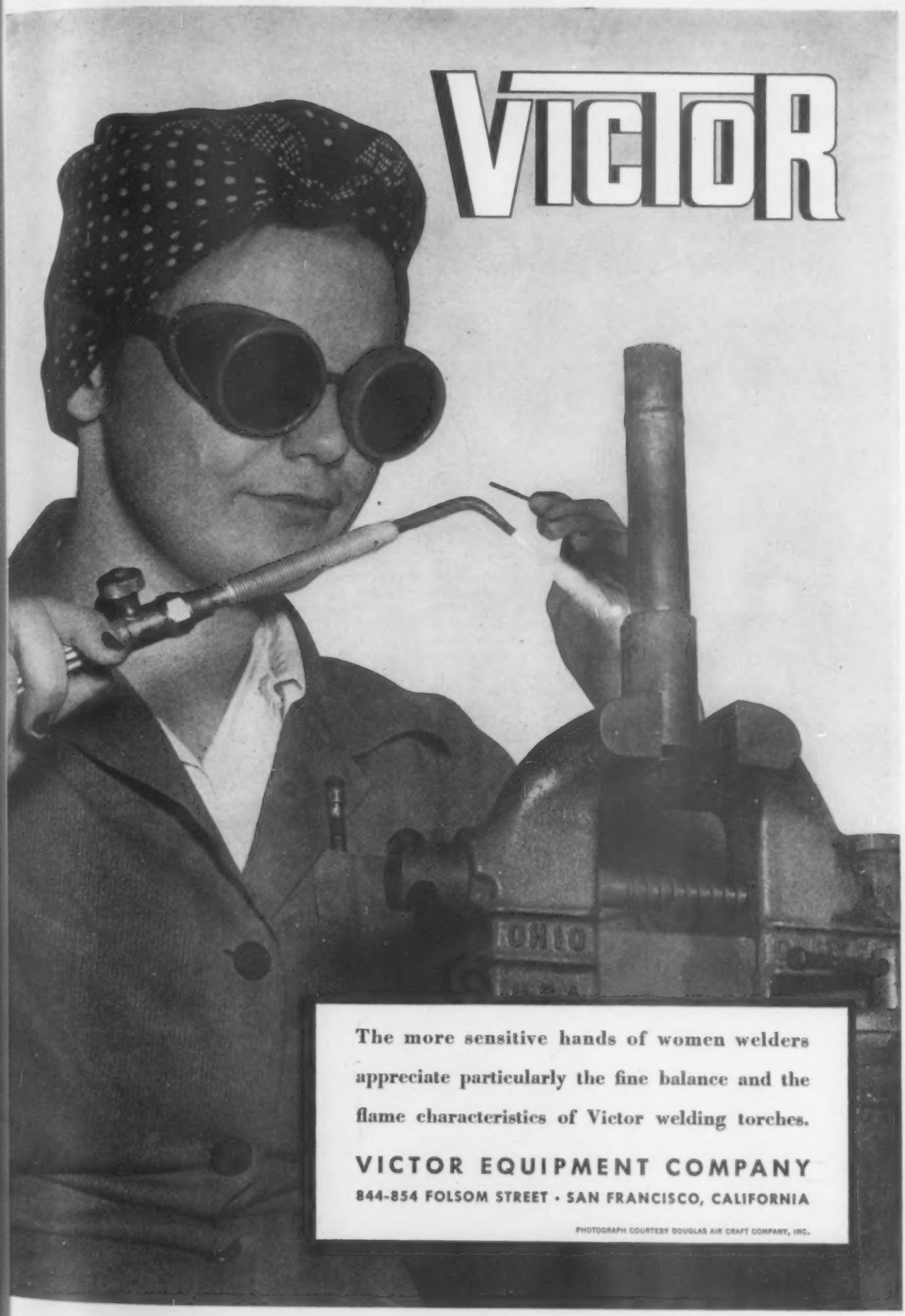
The February meeting of the Chicago Section was held February 19th in the People's Gas, Light and Coke Co. auditorium. This meeting, which was the regular resistance welding meeting of the Chicago Section was one of the outstanding meetings of the season to date. The speaker was C. W. Dodge, engineer, Sciaky Bros., who presented a paper entitled "Control of Pre-Heat Current and Spot Welding of Heavy Gage Aluminum Alloys on Electromagnetic Energy Storage Machines.

In his paper Mr. Dodge presented the results of the latest developments and research being conducted by his organization in the spot welding of aluminum. Information was given with respect to the welding of various gages of aluminum up to $^{3}/_{8}$-in.-thick sheets.

Another outstanding feature of the February meeting was a visit by several of the national officers who were in Chicago making arrangements for the forthcoming Annual Meeting of the AMERICAN WELDING SOCIETY. E. V. David, chairman of the Convention Committee, outlined the plans for the coming meeting while W. Spraragen, Editor of The WELDING JOURNAL, supplemented Mr. David's remarks. Miss M. M. Kelly, Secretary of the A.W.S., also attended the meeting and was introduced to the members of the Chicago Section.

Eighteen technical associations, including the A.W.S., joined the U. S. Army Ordnance, The United States Navy, the War Production Board and other organizations in the sponsorship of the Chicago War Production Clinic. The Clinic, staged at the request of the War Production Board, was held March 11th at the Medinah Club, 505 N. Michigan Ave., Chicago, from 9:30 A.M. to 9:30 P.M.

Chicago A.W.S. members took a prominent part in the organization of the Chicago Clinic. E. R. Seabloom, chairman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of the Chicago Section and supervising engineer of Crane Co. Research Laboratories, was chairman of the panel sessions committee. R. L. Kohlbry, vice-chairman of the Chicago Section, and vice-president of Machinery & Welder Corp., was chairman of the reception committee, and L. S. McPhee, welding supervisor of Whiting Corp., was general chairman of the welding sessions.

Welding accounted for 4 of the 24 panel sessions of which the Clinic was composed. The welding sessions, their times and chairmen were:

Panel No. 8—10 A.M.—Reclaiming of Cutting Tools, Milling Cutters and Broaches by Welding and Brazing. Chairman: T. B. Jefferson, editor, *The Welding Engineer*.

Panel No. 9—10 A.M.—Problems in Resistance Welding of Various Materials. Chairman: R. E. McFarland, engineer, Western Electric Co.

Panel No. 10—2 P.M.—Application of Oxyacetylene Welding, Brazing, Hard-Facing, Flame-Cutting and Hardening. Chairman: H. C. Boardman, research engineer, Chicago Bridge & Iron Co.

Panel No. 11—4 P.M.—Manual and Automatic Arc Welding, Atomic Hydrogen, Thermit, Hard-Facing and Repair of Castings. Chairman: H. J. Kicherer, research engineer, International Harvester Co.

CLEVELAND

The regular meeting of the Cleveland Section was held Wednesday evening, March 10th, 8 o'clock at the Cleveland Engineering Society, 2136 East 19th St.

The main feature of the evening was a paper entitled, "Resistance Welding in War Time Production," by E. A. Mallett, application engineer, The Taylor-Winfield Corp., Warren, Ohio.

His subject covered the various applications of resistance welding to vital war products, in order to expedite and save critical materials in their manufacture. This included spot, projection, seam and butt-flash welding methods as used at present to help speed the day of victory.

Born in London, England, Mr. Mallett came to this country in 1919 to join the Ford Motor Car Co., where he aided in the development of electric resistance welding to meet highly productive conditions. He became active in the design and manufacture of resistance-welding equipment in 1929 and has been closely associated with this work ever since.

The Coffee Talk, "Cannon on Wings," featured a technicolor sound movie of the Bell Aircraft "Airacobra."

Mr. P. H. Merriman of the Glenn L. Martin Co. is scheduled for the April 14th meeting. His subject will be "Welding in Aircraft."

COLUMBUS

The March meeting of the Columbus Section was held on the 12th at the Fort Hayes Hotel. Mr. Elmer Isgren of R. G. LeTourneau, Inc., discussed the subject, "Arc Welding Road Equipment."

CONNECTICUT

The Connecticut Section held a Business Meeting and Dinner on February 16th at the Stratfield Hotel, Bridgeport. Mr. H. R. Kruitbosch of The Electroloy Company, Bridgeport, spoke on the newer resistance welding developments.

DETROIT

Detroit's March 5th meeting was its banner one, more especially from an audience standpoint. "Standing Room Only" was the order of the evening in the auditorium of the Engineering Society of Detroit in the beautiful Rackham Memorial Building. There were many standees.

Mr. Otis Smith opened the meeting and then turned it over to Mr. George N. Sieger, secretary of the Section, in recognition of his efforts in the formation of the Flint Branch which met jointly with the Detroit Section for this evening.

The first speaker was Dr. F. R. Hensel of P. R. Mallory & Co., Inc., who gave a most excellent lecture on "The Metallurgy of Arc Welding Electrodes and Wire." Dr. Hensel was followed by Lieut.-Colonel C. K. McClelland, Assistant Chief of Tank Development, Tank, Automotive Center, who spoke briefly of the welding employed in German tanks and indicated that our own developments and production were of higher order than any yet shown by our adversary. He climaxed his presentation by showing a confiscated German film, produced for exhibition in countries about to be invaded, and featuring their tank production. His message, while most encouraging and enlightening, certainly was a source of much food for thought.

Mr. R. T. Gillette of General Electric Co. carried on with a discussion of "Resistance Welding Electrodes." His presentation followed the unusual method of showing what to do by explaining what not to do. It brought many a chuckle, showing that there was no doubt in the minds of the audience as to the correct resistance welding approach.

LOS ANGELES

The April meeting of the Los Angeles Section is scheduled for the 15th. The subject is "Metallurgy of Welding." The May meeting will be held on the 20th. The subject will be "Resistance Welding." The June meeting will be held on the 17th.

MILWAUKEE

The regular monthly meeting of the Milwaukee Section was held on February 26th at Cudworth Post, American Legion. An after-dinner talk on "How the War Production Board Serves Local Industry" was given by Mr. Frank W. Greusel, District Manager, Milwaukee Office. The Welding address was given by Mr. M. C. Robbins, Handy & Harman Co., who spoke on "Silver Brazing and Its Application in War Work." Mr. Robbins' talk covered the latest developments in the use of silver brazing alloys, including its use in production applications and reclamation of cutting tools.

NEW YORK

The regular monthly technical meeting of the New York Section was held on Tuesday, March 9th, at the Engineering Societies Building. The subject for the evening was aircraft construction. Technical chairman was Mr. E. Vom Steeg, Jr., welding specialist, General Electric Company, New York.

The speaker for the evening was Mr. H. O. Klinke, senior welding engineer, Republic Aviation Corporation, Farmingdale, N. Y., who spoke on the subject, "Welding and Aircraft Construction." Mr. Klinke's paper covered all types of welding processes used in aircraft construction, including arc, gas, atomic hydrogen and resistance welding applications. In addition, he discussed many problems encountered in aircraft welding as well as the qualification and training of welders and processes, and inspection methods for raw materials and finished weld of assemblies. The paper was profusely illustrated with more than forty lantern slides.

Following Mr. Klinke's talk the sound motion picture, "Target for Tonight," was shown. This screen story of the R. A. F. in action on a bombing mission over Germany proved to be one of the best documentary films to come out of the war.

The evening opened with a one-half hour question and answer period conducted by Mr. H. R. Morrison, The Linde Air Products Company.

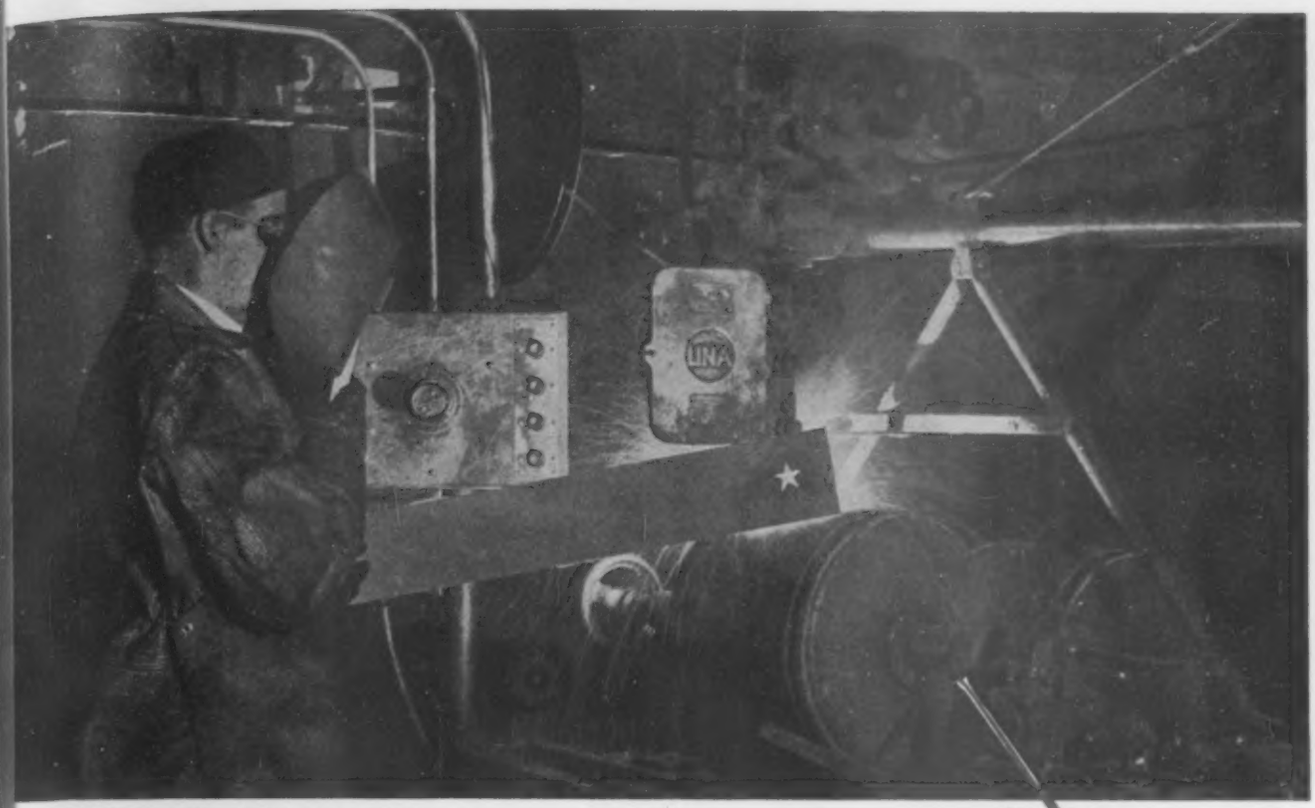
NORTHERN NEW JERSEY

The February meeting, titled "Shipbuilding Night," held on the 23rd, was a huge success. Mr. C. W. Bryan, Jr., vice-president of Federal Shipbuilding and Dry Dock Company, presented some interesting introductory remarks to a talk by Mr. J. L. Wilson of the American Bureau of Shipping. Mr. Wilson had just returned from an extensive tour of the country's shipyards and presented an interesting picture of the more recent construction problems and the recommendations for their solving.

PHILADELPHIA

The members of the Philadelphia Section were the guests of the Philadelphia Chapter, American Foundrymen's Association, at its meeting held at the Engineers' Club on February 12th, our meeting night being changed to coincide with that of the host Society. Dinner at 6:30 was followed by an excellent presentation of "The World in Action" by Dr. Michael Dorizas, Professor of Geography, University of Pennsylvania, who outlined as briefly as possible the statistical factors of importance in the war as well as in the post-war period.

The meeting was opened by Mr. D. J. Peake, Florence Pipe Foundry and Machine Company, Chairman, American Foundrymen's Association, who introduced the officers of the AMERICAN WELDING SOCIETY, and was then turned over to Mr. H. W. Pierce, New York Shipbuilding Corporation, Chairman, A.W.S., who in turn, introduced the speaker of the



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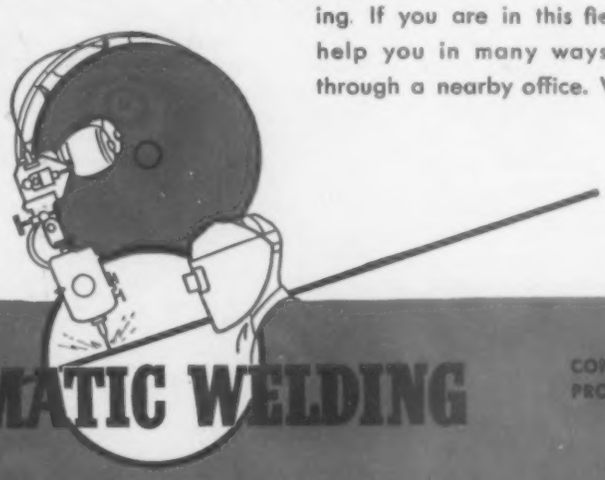

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evening, Mr. Paul Ffield, Materials Engineer, Fore River Plant, Shipbuilding Division, Bethlehem Steel Company.

As an introduction for his talk on "Welding of Castings," Mr. Ffield noted specifically that such welding could not truthfully be referred to as "repairs," but in all cases is actually a "conditioning" operation. When a casting requires welding before being placed in service, it is not the fault of the foundryman but actually the result of poor design in trying to cast an object in one piece or a particular shape that cannot possibly be done without sand inclusions, shrinks or other common imperfections. Mr. Ffield carried this point through the splendid talk which followed, pointing out, with various slides showing actual jobs, ways and means which are being used to correct these design features to permit better casting conditions.

Discussion following the talk brought out the advantages being gained today by the cooperation of the foundryman and the welder in casting comparatively small sections and welding them together to form the finished product, as against two common poor practices: first, the attempt to cast the entire section where its size makes it impracticable; and, second, the welder's effort to eliminate castings entirely through making up the complete section by welding together innumerable small cut and formed sections which, in a great many cases, include such a tremendous amount of "locked-up" stress that the assembly cannot possibly withstand the added strain of normal operating conditions.

The Joint Panel Discussion held in Philadelphia during January was so successful that the Affiliated Societies Council has set up a committee to continue with meetings of this type for the balance of the current season. It is expected that the Philadelphia Section, A.W.S., will conduct two more discussions under this arrangement and we anticipate an even greater success than was experienced in the first instance.

OKLAHOMA CITY

At the February 12th meeting of the Oklahoma City Section held at the Biltmore Hotel, Mr. James A. Hall, of the Kansas City Structural Steel Co., gave an interesting discussion covering the welded construction of landing barges. This talk was very well received by the local section and was the first dealing with barge or ship construction to be delivered in Oklahoma City.

Mr. Orville T. Barnett, of the Metal & Thermit Corporation, is scheduled as guest speaker at the May meeting of the Section.

PITTSBURGH

The Sixth Annual Tri-State Welding Conference of the Pittsburgh Section will be held Friday night, April 30th, in the auditorium of the Mellon Institute of Industrial Research Building, Oakland, Pittsburgh, Pa.

Due to the extremely pressing demands on industry in connection with the war effort and the inability of key men to be present to attend day sessions, the afternoon meeting will be dispensed with this year. However, a "get-together" dinner will be held in the Hotel Webster Hall at 6:30 P.M. before the regular meeting. It is planned to have a speaker and possibly some musical entertainment at the dinner.

The evening technical session will be devoted to a talk on "Welding of Ships," by an outstanding speaker on the subject.

Mr. Bent Laune, of the Eutectic Welding Alloys Company, addressed the members and guests of the Pittsburgh Section on Wednesday night, February 17th, in the Mellon Institute of Industrial Research auditorium, on the subject of "New Welding Materials and Procedure to Salvage Broken and Used Tools."

Following a general description of the processes and procedures for handling various kinds of repairs and reinforcements, Mr. Laune invited questions from the floor and an open discussion followed.

ROCHESTER

The February meeting of the Rochester Section was held Thursday, February 4th, at Todd Union, University of Rochester, River Campus. Professor William J. Conley, of the University of Rochester, presented a very interesting talk on "National Emergency Steels, Their Hardenability and Weldability."

An old-time comedy was presented as the entertainment feature of the evening.

At a joint meeting of the Executive and Nominating Committees, held February 18th, at the Powers Hotel in Rochester, it was decided that, due to the success of the fall bowling party sponsored by the Section, another party of the same type should be held. A tentative date of Saturday, April 10th, was set for this party.

SAN FRANCISCO

The January meeting of the San Francisco Section was held at the Athens Club, Oakland, on Friday, January 29th.

Mr. Mark Casimus, who has spent approximately twenty years in the industry and is qualified to give much valuable information regarding present-day practices in resistance welding applications, presented a paper accompanied by slides showing the multitude of operations and uses to which this type of welding may be put. The latter half of the meeting was given over to the solution of some of the everyday problems encountered. The meeting was brought to a close by the showing of an 8-mm. film which was the property of Mr. Mark Casimus and which was thoroughly enjoyed by everyone.

SAVANNAH

Preliminary Organization Meeting.—The purpose of this meeting was to organize a section of the AMERICAN WELDING SOCIETY in Savannah. This meeting was held in the Civic Room at the Hotel Savannah at 7:30 P.M., February 10, 1943. The meeting was opened by Mr. Roberts, acting temporary chairman, at 7:45 P.M. His talk was given on the purpose of the meeting, which was the starting of a section of the A.W.S. here. There were approximately forty-five prospective members attending.

Mr. Roberts then introduced Mr. Sieger of the S-M-S Corporation in Detroit, who addressed the group on "Resistance Welding" and the advantages of belonging to the AMERICAN WELDING SOCIETY. Mr. Sieger stated that the A.W.S. was the vehicle that made possible our place in industry today. He said, "The sooner we value welding, the quicker we will lick the Japs."

Mr. Sieger also stated that we have thousands of jeeps, tanks, armored trucks, etc., but they cannot be transported to our fighting forces because there are not enough ships to carry them away. He told the difference between welded and riveted tanks and how welding has saved tank operators. Ninety-eight per cent of the jobs designed for riveting are now being welded. Mr. Sieger also said that welding is not a substitute for riveting and they are not interchangeable. He was proud of the way we felt about the welding in our Yard which many told him was one of the best welding jobs on these Liberty Ships. He brought quite a number of samples of resistance welding with him which added to the interest of his address.

Mr. Roberts then explained the different types of membership of the A.W.S. and the advantages of each.

Mr. Wayne then addressed the group on the advantages of belonging to the A.W.S. and how it would benefit the members in the end. He then told about the different types of speakers and movies we would be able to get to address our group.

Mr. Roberts suggested another meeting be held Thursday, February 18, 1943, in the Charlton Room, Savannah Hotel, at 7:30 P.M. for the purpose of electing officers and receiving the applications of prospective members. The meeting was then adjourned at 9:45 P.M. and applications for membership in the A.W.S. were passed out to those attending.

SOUTH TEXAS

The South Texas Section held its regular meeting at the Houston Engineers Club, Houston, Texas, February 11th. Mr. Edward White, western sales manager of Eutectic Welding Alloys Inc., gave an interesting talk, "New Developments in Low Temperature Welding." He stressed the conservation of materials, by using less material in the joints of new installations and by reclaiming broken tools.

After his talk Mr. White presented a film by the International Harvester Company, "Save Those Tools." This picture showed many applications of the eutectic welding alloys in reclaiming tools. The company saved many tools and time by placing the tools back in service right away.

More GOOD WELDS per Man-hour

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OF course, you want more *speed* in welding operations. Who doesn't? But speed alone is not enough. You also want good, strong, clean welds. The Smith A.C. Arc Welding Machine and Smith Certified SW-15 Welding Electrodes is the team that gives you both.

Designed and built to carry heavy loads continuously, the Smith A.C. Arc Welder should not be confused with intermittent-duty machines. We designed this machine ourselves. We built it for our own use in our own huge welding plants where a welding machine *has to be able to "take it and hand it out"!*

NO ARC BLOW—Because this is an alternating current welding machine, there is no arc blow for the operator to "fight." He makes difficult welds *easier, faster,* and *better.*

SAFE OPEN-CIRCUIT VOLTAGE—Open-circuit voltage is about 70 volts and does not vary more than 2 to 4 volts between maximum and minimum output settings. Potential, however, is adequate to strike and maintain the arc easily.

HIGH POWER FACTOR—At full load, power factor is 85% to 90%; at 50% load, power factor is unity; at no load, leading corrective K.V.A. improves the average power factor of the shop line.

OUTPUT CONTROL—Output of the Smith A.C. Arc Welder may be varied *while working* without breaking or altering the fundamental characteristics of the circuit.

SW-15 ELECTRODE—Shielded Arc Universal Type mild steel electrode for flat, fillet, vertical, or overhead welding. While especially suitable for teamwork with the Smith Arc Welder, it also gives excellent results with direct current.
SW-15 is one of the complete line of Smith Certified Welding Electrodes —

Mild Steel... High Tensile... Stainless Steel
WELDING ELECTRODES *Made by welders... for welders*

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WASHINGTON, D. C.

Mr. C. E. Jackson, of the Naval Research Laboratory, addressed the Washington Section on February 23rd, with a very interesting and informative talk on weldability and hardenability.

Employment Service Bulletin

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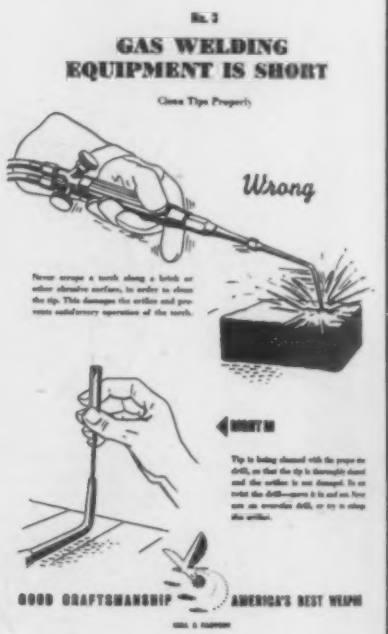
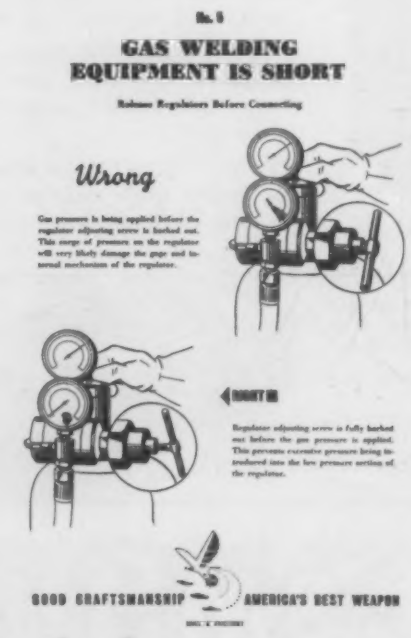


No. 4
GAS WELDING EQUIPMENT IS SHORT
Do Not Use Torch as a Hammer or a Lever
Wrong
RIGHT
GOOD CRAFTSMANSHIP AMERICA'S BEST WEAPON



WELDING has changed the complexion of oil storage tanks

In the early days of the oil industry steel tanks were riveted and it was often difficult to keep the joints tight. It was not uncommon to see dark streaks on crude oil tank shells due to leaks in the joints. Welding has stopped all that. Nowadays those tell-tale streaks are disappearing as welded joints seldom leak. Their higher joint efficiencies also make possible the more economical use of steel plates

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CHICAGO BRIDGE & IRON COMPANY'S PACIFIC COAST YARD AWARDED ARMY-NAVY "E"

The Pacific Coast yard of the Chicago Bridge & Iron Company at Eureka, Calif., was advised on February 12, 1943, that its employees would receive the Army-Navy Production Award for outstanding performance in wartime construction. Presentation ceremonies were held at the yard on February 27th.

The Award also included the local employees of the Mercer Fraser Company, subcontractors on facilities at the yard.

ALEXITE ABSORBIT FLOOR COMPOUND

Fireproof and Sanitary.—AleXitE Absorbit is a four-purpose compound made from AleXitE and other inert fireproof minerals. Never spoils or sours.

1. Absorbs Grease and Oil.—Cover grease spots with compound and sweep back and forth with stiff broom. Allow to remain on grease spots until grease and oil are absorbed.

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4. Dustless Sweeping Compound.—Don't throw away AleXitE Absorbit that has been used to absorb oil or grease. Oil-soaked, it is an excellent sweeping compound. Use it over and over again to take up more oil and more dust. Manufactured by AleXitE Engineering Co., Alexander Bldg., Colorado Springs, Colo.

"HOW TO GET THE MOST FROM ARC WELDING"

A new 42-page booklet entitled "Factors Affecting Increased Welding Production" has just been announced by The Lincoln Electric Company, Cleveland, Ohio.

The contents of the booklet is divided into fifteen different sections, each of which contains up-to-date information concerning specific phases of arc welding such as "Factors Affecting Speed and Cost," "Justifying the Amount of Equipment for Fit-Up," "Where, When and How to Weave," etc.

The booklet is profusely illustrated and carries many charts and tables that are helpful in choosing the correct electrode, applying the most suitable welding technique, estimating speeds and costs of various welding jobs, and other data that will produce the best possible results, reduced costs and increased welding production.

This $8^1/_2$ x 11-inch page size booklet can be obtained directly from The Lincoln Electric Company.

25TH ANNIVERSARY

The American Welding and Manufacturing Company, one of the country's earliest pioneers in the use of welding equipment, will celebrate the twenty-fifth anniversary of its founding on March 29th with a Production for Victory rally and the presentation of service pins to veteran employees.

Principal speaker on the program will be Major W. B. McCelland, U. S. Army Ordnance, Cleveland.

The company was organized by J. C. Manternach, Sr., on March 29, 1918, and produced steel wheel bands for wooden army truck and field artillery wheels during World War I. It had eight employees at that time. Today its employment has increased to nearly a thousand and the company is producing vital parts for tanks; motor and generator frames; steel tubing; bands, gears; angles; channel and flange rings and dozens of other welded parts for war use.

PROPER ELECTRODES SPEED WAR JOB

Production of welded war equipment can be increased by selection of the proper type of welding rod for each job, according to Charles H. Jennings, head of welding research for the Westinghouse Electric and Manufacturing Company, at a recent meeting of the AMERICAN WELDING SOCIETY.

Welding electrodes must be chosen just as carefully as a professional golfer selects the club for each particular shot in a championship tournament. The different types of welding rods have been designed for particular types of work. Steel fabricators responsible for furnishing vital equipment for the armed forces should take advantage of these variations in electrodes.

Overhead welds may require a certain type of welding rod not suitable for flat welding of the same metal and direct-current welding machines may need a different rod than an alternating-current outfit.

The three main factors that should govern the choice of welding electrodes are:

1. *Joint.*—What type of welded joint is required. The weld metal must be high grade if the joint is to last for a long period of time and stand up under rough service.

2. *Weldability.*—This determines the ease with which the welding operator can make the welds. When overhead welding must be done, some rods work more easily than others.

3. *Rate.*—The rate at which the metal from the rod is deposited on the joint directly affects the speed and cost of the work.

ANALYSIS CHART

A new, revised standard steel analysis chart has just been published by American Steel & Wire Co., U. S. Steel subsidiary, to aid wartime steel users.

Embracing all modifications and changes in the analyses of A.I.S.I., S.A.E. and the new N.E. steels up to February 1st, the chart folds up to a small, compact size readily available for easy reference.

A new helpful feature is the breakdown which shows whether or not various types of products are available in specific analyses, together with the listing of the varying amounts of different component elements used in producing the various grades of steel. The chart covers carbon and free cutting steels, manganese, nickel, nickel chromium and molybdenum steels, in addition to chromium, chromium vanadium, silicon manganese and National Emergency steels.

Copies may be obtained by writing on a company letterhead to the Sales Promotion and Advertising Department, Rockefeller Building, Cleveland, Ohio.

RESISTANCE WELDING MANUAL

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- Six Chapters, 288 Pages, 163 Illustrations, 45 Tables—all packed with much-needed information and data on RESISTANCE WELDING—one of the most vital war assembly processes.
- Each chapter compiled and written by a committee of RESISTANCE WELDING experts.

NOTE: *The Resistance Welding Manual* contains all of the resistance welding material originally prepared for the 1942 edition of the *Welding Handbook*, published by the American Welding Society. Therefore owners of this last edition of the *Welding Handbook* will not have need for the *Resistance Welding Manual* unless they wish it in this more compact form, in addition to the *Welding Handbook*.

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